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The Theory of the British Empire

By John Coatman, C.I.E., M.A.

The British empirical approach to politics is perhaps nowhere better exemplified than in the evolution of their imperial policy. It is true that among the motives which led the British to expand overseas was the idealistic one of propagating the Christian religion. But it is possible that this was a less effective inducement than the two more practical reasons, namely, the provision of markets and sources of supply of raw materials and the extension of the King's dominions. It would be untrue to say that our imperial policy during its first centuries was entirely devoid of idealism as it was applied in practice, but it is true that on the whole strategic, economic, and political considerations were dominant, and that policy was determined by events and developments. We have to wait for a long time for any abstract or philosophical thought on imperial policy.

The early literature of British imperial history is descriptive and practical. It is only at such great turning points in the history of the Empire as the American and Canadian revolutions, the beginning of the German challenge from the end of the nineteenth century onward, and the breakdown of the old international system in the twentieth century, that attention is focussed on the nature and objects of the Empire and that attempts are made to frame general concepts of British imperialism. The many settlements or "plantations" of our people overseas were in such different regions, on such different scales, and representative of such different social and religious interests, that it was natural for the Government of this country to deal with each settlement and its problems *ad hoc* as they arose. The planters of the semi-tropical islands of the West Indies were different folk and had different problems from the cod-fishers of Newfoundland, and these, again, differed from the descendants of the Pilgrim Fathers and their conditions and problems, whilst all of them differed from the settlements in Virginia. All these different settlements had their own Charters, their own forms of government, and their own relations with, and means of approach to, the government of the mother country. Therefore, although the broad principles of increasing our trade, extending His

Majesty's dominions, and propagating the Christian faith remained as motive forces of British imperial expansion, no tidy, cut and dried system of British imperial administration did or could emerge, and, no doubt, this was the chief reason why no universal logical or theoretical concept of the nature and ends of our imperial policy was evolved before the catastrophe which destroyed the first Empire.

Nevertheless, an official or governmental view of the relations of the overseas parts of the Empire to the mother country was proclaimed very early in the Empire's history, and, according to our usual empiricism, in response to a specific problem or emergency. This was in 1649, when the Long Parliament passed an Act abolishing the office of King. Straightaway this raised the central constitutional problem of the relations between the mother country and her overseas settlements, the same problem which, in one shape or another, has occupied the attention of Empire statesmen and students throughout the intervening 300 years. It is worth while quoting the actual wording of the 1649 Act, which declared England to be a Commonwealth :

> "the people of England" so the Statute runs, "and of all the dominions and territories thereunto belonging, are and shall be, and are hereby constituted, made, established, and confirmed, to be a Commonwealth and Free State, and shall from henceforth be governed as a Commonwealth and Free State by the supreme authority of this nation, the representatives of the people in Parliament, and by such as they shall appoint and constitute as officers and ministers under them for the good of the people, and that without any King or House of Lords."

Incidentally, it is worth while noticing that all the modern titles of the various members of the modern Commonwealth are included in this extract, namely, Dominion, the title taken by Canada ; Commonwealth, the title now adopted by Australia ; and even the Free State of the Irish Free State of the years after 1921. At any rate, this Act lays down the very important principle of the supremacy of the Parliament of the mother country over all the territories and dominions belonging to her people.

More than 100 years later, when the trouble with the American Colonies was coming to a head, this next major emergency brings forward a similar declaration in the Declaratory Act of 1766. This is how the Act runs :

> " The said Colonies and Plantations in America have been, are, and of Right ought to be, subordinate unto, and dependent upon, the Imperial Crown and Parliament of Great Britain ; and that the King's Majesty, by and with the Advice and Consent of the Lords Spiritual and Temporal, and Commons of Great Britain, in Parliament assembled, had, hath, and of Right ought to have full Power and Authority to make Laws and Statutes of sufficient Force and Validity to bind the Colonies and People of America, Subjects of the Crown of Great Britain, in all Cases whatsoever."

But this governmental view of the Constitution of the Empire was a very inadequate and purely formalistic thing compared with the views which the great clash of feeling and opinion, produced by the developing situation in America, evoked on both sides of the Atlantic. In this country Price and Cartwright in the 1770's and 1780's were preaching a doctrine of the British Empire as an alliance of independent co-operating states. In " American Independence, the Interest and Glory of Great Britain " which Cartwright published in 1775, he argued in favour not only of all that we now call dominion status, but actually went a step farther by asking for a British League to be formed between this country and the colonies, after a formal declaration by Parliament of the independence of the American colonies. Richard Price, in his " Observations on the Nature of Civil Liberty " published in 1776, proclaims the very spirit of the British Commonwealth of to-day when he says " The truth is, that a common relation to one supreme executive head ; an exchange of kind offices, ties of interest and affection, and compacts, are sufficient to give the British Empire all the unity that is necessary ".

But, similar views had been proclaimed already on the other side of the Atlantic. Benjamin Franklin, writing to Samuel Cooper in June 1770 says : " that the colonies were originally constituted distinct States and intended to be continued such is

clear to me from a thorough consideration of their original Charter and the whole conduct of the Crown and nation towards them until the Restoration . . . the several States (in the King's dominions) having equal rights and liberties and being only connected as England and Scotland were before the Union, but having one common sovereign—the King ".

Later in the same year in October, writing to M. du Bourg, he says: "We have the same King, but not the same legislatures". James Madison, writing after the final breach between the colonies and the mother country, but stating the views prevalent at the time, wrote "The fundamental principle of the revolution was that the Colonies were co-ordinate members with each other and with Great Britain of an Empire united by a common executive sovereign, but not united by any common legislative sovereign. The legislative power was maintained to be as complete in each American Parliament as in the British Parliament, and the royal prerogative was in force in each Colony by virtue of its acknowledging the King and its executive magistrate as it was in Great Britian by virtue of a like acknowledgment there. A denial of these principles by Great Britain, and the assertion of them by America produced the revolution.

In these and other writings we have the essence of the modern doctrine of the Balfour Declaration, and, even, the foreshadowings of the position to which we are moving after the second world war 20 years later than the Balfour Declaration, most clearly stated. The writers mentioned above were voicing opinions and doctrines which had considerable vogue both in the colonies and in this country, and it is therefore strange that after the disruption of the first Empire, with the Treaty of 1783, the imperial policy of the British Government should have become in some respects more authoritarian than ever before. For example, after the American Revolution, colonial Charters such as the Canada Constitutional Act of 1791, were granted by parliamentary statute and not by orders in Council. This was in effect to implement the doctrine contained in the Act of 1649 and the Declaratory Act that the overseas possessions of Great Britain were subject to the will of the British Parliament. Colonists, therefore, could no longer say that they had allegiance

to the Crown but not to Parliament. In practice, too, the British Parliament often intervened directly in the internal affairs of the colonies. The abolition of slavery in 1833, for example, was an unprecedented interference with colonial internal affairs. Therefore, the idea, which is widely current, that the Parliament and Government of this country adopted a *laissez faire* policy towards the colonies is not true. What is true is that successive governments of Great Britain attempted to continue the government and administration of the Empire from this country, and even men of enlightened views and considerable knowledge of imperial affairs could not see how the unity of the Empire could be maintained unless the control of the mother country over the affairs of the colonies was continued unimpaired. This view comes out very clearly in George Cornwall Lewis's "Government of Dependencies" which was published in 1841.

The important school of thought led by Bentham had a purely negative attitude towards the Empire, which is best illustrated in Bentham's own pamphlet "Emancipate your Colonies". Like Bentham, James Mill and Roebuck both saw colonies as possible societies of corruption in English public life, and costly luxuries into the bargain. It is true that Bentham changed his views somewhat later in life, but it is unfortunate that Utilitarianism did not take up and develop the most fruitful conception of imperial relations which could have been such a valuable legacy of the American Revolution. Nevertheless, Utilitarian thought, the progressive views of Price and Cartwright, and the more effective progressive views of Burke and Fox, were destined to have lasting influence on the policy and the fortunes of the Empire in the work of Lord Durham. For half a century after the Treaty of Versailles it looked as though the remainder of the old Empire in North America was to go the same way as the 13 colonies. The rebellions of 1837 in both upper and lower Canada were the outcome of the monopolistic centralised government of the colonies by the mother country, and Durham's famous and entirely successful solution of the problem presented by the demand of the colonist for effective control of their own domestic affairs owes a good deal to Benthamite teaching and to both Fox and Burke. For his cardinal principle of the need to

establish an identity of interests between government and governed, derives from Utilitarian teaching joined with Fox and Burke's principle of liberty and self-government.

The history of the Empire for the next 30 years after Durham, down to 1870, the end of the old system of attempted control from Great Britain, is a story of the gradual application of the principles of the Durham report and the experience of the Canadian provinces, to the other colonies. Even so, the true character of what had happened in Canada was not perceived in this country in those days. In fact, to many observers, notably to Disraeli, who could write to Lord Malmesbury of "these wretched colonies which hang like a millstone round our neck", and Lord John Russell, who, in an official dispatch to the Governor-General of Canada, looked forward to the time when the colonies would declare their independence of the mother country, it seemed as though there were nothing but dissolution in front of the Empire. But this was because the true nature of the Copernican revolution in imperial policy and administration, which had taken place in Canada, was still unperceived. Certainly, the unity of the Empire in the sense of control from one centre had gone, and quite clearly a group of nation states were growing out of the soil of the old Colonies. And, to many middle nineteenth-century eyes, no effective and permanent ties could be perceived to keep these evolving nations within one political system. A federation of the different British countries, statesmen of those days could no doubt have understood; indeed, in the days of the old colonial reformers whose thought and work had been such an immensely important factor in developing Durham's own views and in making it possible for them to be brought into effect, Molesworth had actually sketched out a Bill for a federation of the Empire.

Happily, no serious attempts were ever made, in those days at any rate, to bring about an imperial federation, for that really would have destroyed the Empire. The explosive force of the nascent nationalism of the young colonies would undoubtedly have burst through the mechanical political trappings of federation. Like the thirteen colonies of the first Empire the colonies of the second Empire simply had to tread the road to nationhood, whatever the result might be for the imperial connection, and,

in the middle decades of the century, even the most intelligent observer might have been pardoned for expecting the colonies to go their own way independent of the mother country once they had attained full national stature and could look after themselves. But this did not happen, and the reason why it did not happen is of the utmost significance, not only for the British Empire but for the whole world.

The reason is, that the grant of responsible government to the colonies coupled, as time went on, with fiscal autonomy, gave them all the scope they needed—spiritual and mental as well as political and economic—to work out their own conceptions of nationhood. On the side of the mother country, there was toleration of this process, albeit a pessimistic toleration on the whole, and the prevailing " climate of opinion " in our national politics and economics, namely, that of the Manchester School, was not actively hostile to the Empire in spite of the pacifism and anti-imperialism of men like John Bright. Therefore—and this is the important point—time was given for the new relations established between 1840 and 1870, to perpetuate themselves as a dialectical, and, consequently, dynamic set of forces. Of course, this was not perceived at the time. I am not sure that it has been perceived at all widely even now. Nevertheless, this was the great creative discovery in inter-imperial relations which the British colonies and the mother country between them had stumbled upon simply by following the logic of events and of their own spiritual dialectic and the ideas and institutions which were its outcome. It is a discovery comparable to the other and earlier major political discovery made by the English, namely, the truly creative institution of parliamentary government.

It is desirable that this should be understood clearly, because the British Commonwealth of Nations is something new in political association. It has developed during the last half century or so into an association of completely independent sovereign states. It is not an alliance, it is not a union, it is not a federation or confederation, but an association. Yet the whole system, conscious though its member parts are of their own independence and individuality, forms a unity. To us who belong to the Commonwealth, the individuality and independence

of its member units tend to be more apparent than the unity of the whole. But anyone who has had to study foreign writings on the British Empire realises that foreigners are more conscious of the unity of the whole than of the separateness of its parts. It is very striking, too, to notice how puzzled foreigners are to account for the British Commonwealth, and how earnestly they search for some tangible or rational and comprehensible bond of union between the parts. Of course, some British writers do the same thing, but the truth is that the British Commonwealth to-day consists in the relations between its different parts. The essential things about the British Commonwealth to-day are not the political status, the strength, nationality, economic resources, trade, or anything else, of its constituent parts, but simply and solely the relations which exist between them. These are relations between bodies scattered in space and, so to speak, dispersed in time also, because if we can think, as we can for certain purposes, of the history of civilisation as a secular process, then in the British Commonwealth to-day there are peoples who are at the beginning of that secular process, others who are some way advanced along it, and others who are farther advanced still. Yet the relations between these very different members of the Commonwealth are very different from those which we call international relations; the relations, that is, between nation states which have no bond or principle of association between them. There is no need for me to elaborate the differences between inter-imperial and ordinary international relations. But one all-important difference leaps to the mind. There is no possibility of war between any of the members of the Commonwealth. In a word, as long as the British Commonwealth is in existence, about a quarter of the earth's surface and its peoples are withdrawn from the anarchic "state of nature" system of the relations existing between sovereign nation states.

Let us carry our analysis a step further. Although the British Commonwealth is a unity, it is not a unity in the same sense as an ordinary nation state, or conglomeration of peoples or territories like the Soviet Union, is a unity. That is to say, there is no one central, sovereign authority for the whole, and in international affairs it does not speak with one voice like the U.S.S.R. or the United States. At any rate, when it does, the

unanimity is the result of free agreement reached by prior discussion and is not the decision of one central governing authority. Such agreement is never the result of a majority vote, since majority votes and coercion find no place whatever in our Commonwealth relations, at least, in the relations between those members who are also members of the United Nations Organisation. When agreement is not possible, disagreement is no indication of hostility or rancour, and the dissidents realise that, although their own particular interests or opinions impel them to disagree, nevertheless their particular interests are still only one element in the wider interests of the greater entity which is the British Commonwealth.

The significance of this for the world and international relations in general is surely apparent. The world has not yet learned how to transcend the interests of sovereign nation states in the interests of the whole. The League of Nations, and now the United Nations Organisation, are recognitions of the need to transcend the interests of sovereign states in the interests of the whole, and are attempts to achieve this. But it is obvious that this achievement, so far from having been completed, has not, in fact, been even begun. The greatest difficulty in the way of making the United Nations Organisation what we want it to be is precisely the unwillingness of all concerned to abate their full autonomy, as sovereign nation states, in their relations with each other. The difference between a world constellation of sovereign nation states and the British Commonwealth is the difference between a universe conceived as governed by the laws of Newtonian physics and the universe of the relativity theory.

For the concept of the sovereign nation state is the concept of an absolute, existing in absolute space and time, and with absolute functions conceived as arising out of the nature of the nation state. It is, in fact, a sort of Platonic form, and the nation state in the world of human activity is but an incomplete form of this, ever striving to attain the perfection of the ideal. At any rate, the concept of the sovereign nation state is a static and fixed concept from the point of view of a world society, and history and our experience to-day, show how very difficult it is to see how there can be any transition from this system of independent

absolutes to an all-inclusive whole. The modern concept of the British Commonwealth of Nations, however, has none of this static quality, but is, on the contrary, a true example of a dialectical system whose real existence is found in the developing relations between its parts. To carry on this metaphor, it can be seen that the functions and nature of each separate unit of the British Commonwealth depends on its position in relation to the others, an also on the speed of its progress towards political maturity—nationhood, if you like—as compared with its fellow members of the system. Thus, the fact that Canada is at all points a sovereign nation state like Great Britain herself, makes it in no way incongruous that she and Great Britain should be parts of a system which include Fiji or Kenya or Ceylon or India. I have chosen these examples because you will notice they all occupy different places in the Commonwealth system—different political places, that is—and the speeds of their advance towards the position occupied by Canada and Great Britain vary between themselves. But even Fiji and Kenya share in the life of the whole and are affected by it. Perhaps the best illustration of what I mean is given by the experience of India.

The first truly constitutional development in the relations between India and this country came with Pitt's India Act of 1784, which for the first time gave Parliament direct responsibility for the good government of India. This Act was a direct outcome of the ferment of reforming activity in this country which was itself a result of the American revolution. Then as the nineteenth century advanced, and it was found necessary from time to time to reform and improve the system of Indian government, certain fundamental principles—not pieces of political machinery, but principles—of our own democratic system of government, were introduced into the government of India. Thus, by the Charter Act of 1833 (and note the synchronism with the first reformed Parliament) the principle of equality of all British subjects before the law, and equality of opportunity for government employment was brought into the system of government in India. In 1861 the Indian Councils Act of that year brought the first introduction of the principle of representative government into India. Again, note the synchronism—the Viceroy of India was Lord Elgin, the same Lord Elgin in whose

time responsible self-government had been made a reality in Canada by his full acceptance of all the implications of the Indemnity Act of 1848 in that country. Already we have seen the influence of our old North American colonies on India, and now we see the influence of Canada. In 1892 another Indian Councils Act brought into Indian Government the principle of election of representatives, the outcome of the years of Liberal ascendency in this country. Next, in 1908 the Morley-Minto reforms considerably increased the scope of these basic principles of representation and election, and gave far more real power to the representatives of the Indian peoples in their own government. Again, mark the synchronism. This followed hard on the extension of responsible self-government to the Union of South Africa including the two Boer Republics lately at war with us, and the Morley-Minto reforms were conceived and executed by the same government as had extended responsible self-government to South Africa. So we see the interaction of the different parts of the British Commonwealth on each other. I do not wish to go into greater detail in this particular argument, which could be matched by others, but I think it is clear that it is right to speak of the development of the British Commonwealth of Nations as a dialectical process in which the structure and functions of the Commonwealth are determined by the relations between its different parts.

A similar argument could be advanced with regard to the political and spiritual progress of the members of the dependent part of the Empire, the areas which we now call colonies, as distinct from the dominions. India is the meeting point of dependent and free in the British Commonwealth, and she has passed through all the stages which are now exemplified by the very heterogeneous members of the Commonwealth, from absolute government to independence to-day, that is, if the internal conditions of India allow her to exercise it. The doctrine of trusteeship in colonial affairs, which has now developed into the doctrine of partners—a very fruitful concept—arose out of the membership of the colonies concerned of a Commonwealth based on the principles I have been expounding.

And there is a further most important aspect of Commonwealth relations to be noted. We see to-day how the great obstacle to

Indian freedom and independence is the deep-seated cleavage of interest between certain Indian communities and peoples. Analogous cleavages are seen in Canada and South Africa, and in Ireland also, and in all these countries, men and women of vision see that their only hope of united nationhood is within the British Commonwealth. It already seems obvious that even the Congress Government in India is beginning to realise this condition and there are strong hopes that India will, in fact, remain a member of the Commonwealth, although no doubt on different terms from any of our present dominions. The same is true of Ireland. Mr. De Valera has expounded a theory of Commonwealth connection for Eire which only the Irish mind can understand, if, indeed, it does understand it. Nevertheless, connection with the Crown remains a necessity for Eire, and it is likely to remain so for India. The same is true of Canada and South Africa. The French and the Dutch would hardly be able to remain united in organic political association with their fellows of British origin unless they were inside the British Commonwealth. In a word, a close and informed analysis of the structure and life of the British Commonwealth reveals it as a system of mutually influencing parts with no static concepts to hamper its free development of which the motive force is simply its own spiritual dialectic.

The existing constitution, or, at least, theory of the British Commonwealth, is summed up in the Balfour Declaration of 1926, and its statutory embodiment in the Statute of Westminster. The declaration concerns only Great Britain and the dominions, but the theory of the Commonwealth as I have expounded it, makes Lord Balfour's formula applicable "sub specie aeternitatis" to all the other members of the great association. This is how the essential part of the Balfour declaration reads :—

> "They are autonomous Communities within the British Empire, equal in status, in no way subordinate one to another in any respect of their domestic or external affairs, though united by a common allegiance to the Crown, and freely associated as members of the British Commonwealth of Nations."

But even this concept of the Commonwealth, wide and general as it is, has now to be expanded and developed, and I think we

can already see the next stage to which the Commonwealth is moving. The concept of dominions status is being transformed into the concept of a society of nations. Here again we see the truth of all that I have been saying, because India and Eire will perhaps play a greater part than any of the other members of the Commonwealth in shaping this new and undoubtedly still more fruitful concept. Indeed, the theme is a fascinating one, and the history of the British Commonwealth has all the elements of great drama. We have traced its developments from monopolistic rule by the mother country through responsible self-government to dominion status, the latter stage being reached incidentally after a prolonged attempt in certain quarters not only in this country to form a federation out of Great Britain and her colonies, a system which would have become as static as the ordinary nation state, and would have been no more than a glorified nation state, somewhat on the lines of the Soviet Republic, although, of course, without the Marxist ideology and certain other factors of the Soviet system. It can hardly be denied, I think, that in the British Commonwealth, as thus expounded, we have the basic principle of a future world order. Ideas of a federation or a United States of Europe, and the like, are not only dreams, they are simple monstrosities, for any such development would only be adding another glorified and extensive nation state to join the U.S.S.R. and the U.S.A. But in this concept of a society of nations towards which the British Commonwealth is now advancing we have a concept in which all the people of the earth may in due course find a secure resting place, in an association capable of self-adaptation to changing conditions by the creative force of its own spiritual dialectic.

Freedom in Education

By Eric James.

The subject of freedom in education is worthy of study for several reasons. The great reorganisation and expansion of our educational system which is at present taking place necessarily raises a great number of questions both of personal and of institutional liberty. Further, and more important, the relation between education and society is a particularly interesting one. Education is, in one of its aspects, a means for the transmission and perpetuation of moral and cultural standards : in another, it is one of the most powerful instruments of social change. Thus it is related to society both as a stabilising and as a revolutionary force, and is therefore particularly sensitive to the ideas of freedom and authority current in society itself. We are concerned, moreover, as part of education with teaching immature people our beliefs upon the most important questions, of which freedom itself is one. We should attempt therefore, in considering the relationships between freedom and education to discuss our beliefs in less ambiguous terms than we often do in considering freedom in other contexts. The teacher, since he is dealing with social organisation in a fairly limited and defined field, and one where clarity is essential, finds himself called upon to answer with unusual directness questions which have important bearings upon moral and political philosophy and on theories of society. It is for these reasons that a discussion of freedom in education may be held to have interest for others than those professionally concerned with it. We may see the extent of the questions involved if we consider an apparently simple expression of educational faith that in one form or another is heard often enough : "We must make our children into good citizens." Quite apart from the vistas of ethical and political theory opened by the words "good citizens", the word "make" raises issues of freedom in the school and the word "we" those of ultimate responsibility in education that are too often unsuspected by those using such phrases. It is, indeed, the principal aim of this paper to show the generality of the questions that arise from what may appear to be a limited subject.

The subject is actually all too wide for a single essay. For liberty is concerned with the proper adjustment of relationships,

and in education a number of different kinds of relationship are involved. The relations between the teacher and the pupil, the teacher and the school, the school and the parent, and the school and various outside bodies, one of which may be the State, are all capable of raising questions of the proper extent of authority. Thus when we speak of liberty in education we must specify with the greatest care which particular kind of relationship we are discussing. It is for lack of such precision that there is the greatest confusion in current educational literature in the use of such phrases as " a genuinely democratic education".

We may find, perhaps, the most suitable starting point for our inquiry in the relations of pupil and teacher. In no field of education has there been a greater change in the last century, and particularly in the last twenty-five years, than in the degree of freedom allowed to the child. It would be interesting to analyse the various factors that have led to that change : the romanticism of Rousseau and of Wordsworth, the humanitarian movement of the last century, the deeper force of humanism with its regard for the individual judgement and personality, even of the child, have all contributed to the movement towards far greater liberty. Two hundred and fifty years ago even as superficially advanced a writer as Locke put absolute obedience high among juvenile virtues ; Wesley's celebrated advice, " Break their wills betimes : begin this work before they can run alone, before they can speak plain, perhaps before they can speak at all, whatever pains it costs, break the will if you would not damn the child . . . " shocks us even more than it shocked his biographer Southey. The difference between this and ordinary contemporary practice is striking enough ; the contrast with the most extreme modern doctrines is that of two religious systems. The Augustinian theology of Wesley led him to the view that since the inclinations of the child are naturally wicked, liberty has too many dangers for him. It is important to recognise that the school of completely free expression rests upon a no less dogmatic belief in natural goodness, though this doctrinal basis is not usually explicit. A point of view diverging from both of these in foundation, though leading to an authoritarianism similar to the former, is that which sprung from Plato. If we believe that the knowledge and experience of some adult minds gives them some knowledge of

the Good, have we not an obligation to impose upon the young the standards so obtained? If this view is adopted there is only a very limited place for legitimate liberty in this department of education. This is a question to which we must return. At this point I will merely draw attention to an inconsistency in the views of those who advocate complete freedom for the child from restriction or even guidance. Mr. A. S. Neill, for example, one of the most notorious of such advocates, admits that in questions of personal cleanliness authority must impose rules of behaviour in order to preserve health. The weakness of this admission is obvious. If the health of the body necessitates limitations on the child's freedom how much more the health of the soul, replies the Platonist or the Christian. And to defend himself from this attack, the libertarian must retire into an agnosticism concerning any except the most material aspects of life so profound as, in the opinion if many, to disqualify him from legitimately assuming the title of teacher, and certainly sufficient to prevent him from believing, for example, that freedom is a good. It is, of course, such agnosticism that has been one of the contributory factors in the growth of libertarianism in education. In the moral and spiritual spheres there are few things that some teachers regard as certain enough to make the basis of an imposed code of belief and action.

In addition to an increased liberty for the individual child, there is also a contemporary movement, likely to be of more importance, that gives greater liberty to children as a group in the school as opposed to other authority, a movement that obviously owes much of its impetus to the development of political democracy. If we are to educate for a free society must not the internal organisation of our schools be on democratic lines? So runs the argument. It is not always clear what is implied by the word "democracy" in these contexts, and, indeed, in educational matters there is nearly always a regrettable vagueness and misuse of such terms. Often what is meant is an oligarchy of prefects. But from the general idea springs various experiments, some of undoubted value, involving school councils, form parliaments, and similar devices of self-government in the schools. Attractive though many of these schemes are, they must be examined most critically, for in my view they are dangerous for

several reasons. Such experiments make the assumption that patterns of behaviour inculcated in childhood will express themselves in homologous terms in adult life, that is to say that the child who has practice in electing his form captain will be more likely to become an active and intelligent voter than one who has not. This assumption is at present without any great foundation. On the other hand it is an experimental fact that children can be extremely cruel and undoubtedly unjust, and any system which gives them the freedom to tyrannise over others in the name of liberty is full of danger. Further, among the principal psychological needs of children is security. A system that may give the impression of an absence of fixed rules, and in which too many alternatives are open to the child's own choice, lays a responsibility and a sense of lack of order upon the child that may well be too heavy. Such systems of self-government also often have an essentially unreal character that children are quick to recognise. In practically no school could a vote of the school council succeed, for example, in getting the school hall painted crimson, or in eliminating some essential subject from the curriculum. At such a point authority would step in, and the reply "But they would never *ask* a thing like that" indicates the unreality that underlies many of these experiments in so-called democracy; they are only prepared to tolerate freedom as long as it produces the results we want. In so far as the lessons learned at school are carried on to adult life, then the practice of a counterfeit democracy in which real power does not lie with the "people" might be held to produce a subsequent distrust of the whole idea. The school is a community which, in fact, is not comparable to a state of adult citizens. We do no service to democracy, the most onerous of all forms of government, by imagining that it is workable in any real sense by children of twelve or fourteen: we do no service to the children by laying on them responsibilities which are our own. This is not to say that we must fall back on a pure authoritarianism, which tells the child what is the right course, and exact obedience. We must not forget the educative effect of making choices. It is possible, however, to have such scope for choice, as it is to employ methods of co-operation and consultation at

every level in the school, without the apparatus of spurious and inappropriate democratic forms.

There is one further aspect of freedom in the relationship between pupil and teacher ; that which concerns the choice of the subjects of study. Obviously the consensus of opinion is in favour of some very clear restriction in the earlier stages, since the essentials of literacy are necessary for any kind of further study and for citizenship itself. But beyond the primary stage there is no such agreement. In America, with its libertarian tradition, there is little in the nature of a compulsory core of studies, and the widest liberty of choice is permitted. In this country our attitude still tends to be more restrictive. In schools of the grammar school type, at any rate, there are usually a number of compulsory studies and the universities lay down, as is well known, a certain standard in a group of subjects for all their entrants, whatever their specialism. Such a restriction of freedom is manifestly based on the idea that there is a core of knowledge which all educated men should possess, though it is curious and unfortunate that little definite thought has gone into the positive formulation of what constitutes that body of knowledge in a democratic community, for individuals of different levels of intelligence. There is, in my view, no more difficult and important educational task. It is interesting to see that in America where the freedom which could regard unrelated courses in world history, agricultural chemistry, English grammar and physical education as an adequate preparation for citizenship, has hitherto flourished, there are now signs that the idea of a basic liberal education is gaining ground, whether in the form of the 100 necessary books as at Chicago, or in the prescription of certain groups of studies as in the recent reports from Harvard and Columbia. In this country, on the other hand, forces are at work which will certainly have the effect of increasing the child's freedom in the choice of subjects and diminishing the obligatory elements. In my opinion such a tendency is almost entirely lamentable. I believe that unless we realise that for various abilities and aptitudes there are groups of subjects more valuable than others, our whole society will be the poorer.

I have indicated thus far that my attitude towards the pupil-school relationship in the three broad fields of moral teaching,

general organisation and intellectual training is rather more authoritarian than is at present fashionable, for in all these aspects of educational activity I feel that though authority must be more rational and less arbitrary than it has sometimes been, yet authority there must always be. At once a new question presents itself : Who should be the guardians of this authority in our schools and universities ? In this very complex question there is really a group of problems ultimately largely philosophical in character. They are, moreover, of great practical urgency at the present time, and underlie in one form or another much contemporary controversy.

We have passed through phases in which the church or the State have dominated much of English education, but we have also had, and still have, the position in which most of the finest educational institutions are controlled by the teachers themselves, or by special governing bodies of their own. What, we may ask, is the appropriate form of government, and how much power should it exercise ? If we agree that the headmaster should be able to tell the school council that he will not have the school hall painted red, we must decide who is to issue similar prohibitions to the headmaster. In fact the controlling authorities may be the central government, the local government, or a body of governors, and vaguer though real forces include such influences as that of parents or of religious bodies. In questions of curriculum we must add to these the demands of universities, of examining boards, of professional bodies and of industry. The forces which limit the freedom of the school, which in this context means the teachers and headteacher, are thus numerous and overlapping, and their authority differs in weight with the kind of school and with other variables. We thus have to dicuss not only how much control over liberty there should be, but also which body is appropriate to exercise it. At the present time in education, as in much else, control is becoming more concentrated in the instruments of the state or of local government, and it is this tendency which gives rise to much contemporary concern since it is feared that this must lead to " loss of liberty ". Yet on the other hand it may well be argued that in a democratic state, since power must rest with the people's elected representatives, must not education as one of the most important aspects of the national life, most

urgently demand such control ? Does not the undoubted distrust of such control, particularly when exercised by the agencies of local government, really show a fundamental distrust of the democratic idea itself ? To some degree I believe this retort to be justified, and the fear of state control and even of local control of education to be ill-founded. But the position is more complex than it sometimes appears, and in considering the apportionment of ultimate authority for the conduct of schools the following factors must be borne in mind.

First, ability tends to follow power, and if the powers of individual teachers are too much curtailed, as some local authorities tend to do, the calibre of men and women wishing to teach rather than to administer will decline, with disastrous results. Second, in a democratic society, dispute should be dealt with as far as possible by discussion. Such discussion is only fruitful if it follows from personal contact and interest, and therefore I believe that the claim that every school should have its own governing body is well founded, even if that body is but an intermediary between the school and the ultimate democratic authority. Thirdly, and this is by far the most important point, it may well be that some elected bodies really are incapable of exercising authority wisely over the whole field of education. For consider, in the light of what we have said, how wide that field is. The ultimate authority is not concerned only with bricks and mortar, with enforcing literacy and with seeing that public money is wisely spent : it is charged with the transmission of moral and cultural values, with their reassessment, and with their change. We are at this point brought against a fact that is not usually realised with sufficient clarity, and from which much confusion springs : under the term " education " we are accustomed to include an immensely wide range of problems, from the purely material to the deeply spiritual ; the work of an omnicompetent education authority would range from the problems of plumbing to those of belief. It was for this reason that in the Platonic Republic the highest duty of the guardians was the supervision of education. In the absence of philosopher kings it is doubtful whether any one body can or should be the ultimate authority on questions from different parts of so wide a field as that comprehended in the single word "education". There

are few who seriously maintain, for example, that local education authorities are competent to administer universities. Yet the spiritual and intellectual problems involved in the highest forms of some schools are not vastly different from those of the university. It is, of course, true that over many areas of education the elected authority is perfectly fitted to be the final arbiter. It will probably be admitted that society has the right and the duty to impose certain minimum standards upon schools and parent—standards of health, of attendance, of pedagogic competence, and so on, and for the discharge of these primary obligations the elected authority is probably the right instrument. But over other kinds of question it is by no means necessarily so. Its incapacity usually is, and should always be, greatly mitigated by the device of co-option. But some element of incapacity remains, and it is a vague and largely inarticulate feeling that there are certain fields of education beyond their scope that leads to the often misdirected and doctrinaire rejection of the idea that they should have any authority at all.

It may, of course, be objected at this point that local education authorities have the advice of experts in their directors and their staffs, while the central government has both an administrative staff and an inspectorate. But if, indeed, the Directors are to direct, the concentration of power over a social force as potent as education in so few hands offers great dangers, and these dangers are, at any rate theoretically, not lessened by the high qualities of many of those who at present hold these positions. When we remind ourselves yet again that the ultimate authority in educational matters is concerned with ends as well as means, and with the ways of embodying the values of our civilisation in an educational system, we shall agree that just as the individual headmaster is not necessarily competent to be the final judge even over a limited field, neither is the director by virtue of his office. The liberty of both must be subject to higher authority. It was for this reason that the director who is perhaps more fitted than any other I have met to pronounce on questions of value remarked that he disliked the phrase " director of education " as implying far too great a concentration of power. The same reservations must be made concerning the central government as the ultimate authority in education. In short,

though the individual school should be prepared to accept the direction of a democratic central and local government in a number of matters affecting its life and work, and though it must listen with respect to their advice on the content and final direction of education, there legitimately can and should be misgivings when it is suggested that their direction in these matters should be absolute. The questions we have to answer concerning educational freedom are thus not only " Who shall exercise authority and how much authority shall they wield ? ", but also : " In what specific fields of educational work is a particular body thoroughly competent to speak ? "

It is usually, then, for the content and ultimate idealism of education that we are concerned when we use such phrases as " academic freedom " or when we show apparent distrust of the democratic method by referring to " outside interference with the schools or the universities ", though those who speak in this way do not always realise the aspects of education in which their concern is most justified. For such concern arises from a not altogether articulate realisation of the quite fundamental character of the forces latent in educational institutions. The demands, for example, that " politics should be kept out of education ", though strictly impossible since, as Plato showed conclusively, the two are almost aspects of the same problem, have nevertheless a foundation in the feeling that we mean something by " the tradition of culture " which should maintain a degree of continuity in spite of changes of power within the state, and to this extent should transcend as far as it may its authority. Nevertheless the content of education, with all that it implies, must be under some control. It cannot be left to the unsupported opinions of individual educators. What then is the appropriate controlling force if the elected bodies in the state and their servants are felt to be incompetent for this particular task ?

Ultimately the sovereign power in this field of education can only be the consensus of academic opinion, working through a variety of agencies. In practice this is to a great degree the method by which control is at present exercised. Through examining bodies, co-opted members and representatives of learned institutions on educational committees and governing bodies, through professional organisations of teachers and the

Ministry's inspectorate, and through committees appointed by the Ministry for various educational purposes, the clerisy makes its influence felt and curtails the freedom of individual educators. It would be difficult, for example, for the head of a grammar school to abolish the teaching of French in his school. He would be called to account by certain of his governors, by the fact that his pupils would find it difficult to enter universities, probably by His Majesty's inspector, and the disapproval of a number of his colleagues would be added to the influence of the more official forces. He would not, I think, be violating any definite ruling of educational administration that French should be taught in all Grammar schools, but rather the common belief of the English clerisy. That such forces are at work to maintain the character and the standards of the content of education is perhaps so obvious that it may be thought not worth mentioning. Yet I believe that it is a fact of great importance, for the guardians of this tradition are not sufficiently conscious of their function, and there are, moreover, tendencies developing in our society which may either destroy this control and replace it by a disintegrating libertarianism, or hand it over to bodies which are incompetent to discharge it. It cannot be maintained that the academic class, which I have called for want of a better term the " clerisy ", now feels any real sense of responsibility for the character of education as a whole. Its interest is lukewarm and inexpert, when it is not purely sectional. Nor is this surprising when we consider what has happened to this class under the pressure of social and economic changes. It has expanded enormously and it has lost homogeneity. It includes as partners in the work of education the professor of metaphysics and the teacher of metal-work, and the teachers of metal-work enormously outnumber the professors of metaphysics. Further, the disintegration of the clerisy into specialisms, even at the higher levels, has created a grave lack of concern for the nature of education in its broadest sense, and one result has been that the most fundamental questions of educational policy, such as what shall be taught in a rapidly changing social and cultural environment, have not been discussed at all, or have been treated superficially, or have been left to the less wise and experienced sections of the academic class. The

very conditions which make such discussions more than ever vital have made them the less often conducted.

The danger is apparent when we consider the abrogation of responsibility on the part of the universities which is implied by the creation of professorships of education. We may have unquestioned experts on the history of education, in the techniques of testing intelligence, in child psychology, or even in the practice of teaching. But such experts need not necessarily have a truer vision of the proper ends of education in its fullest sense than a professor of mineralogy, though some of them do, of course, possess such a vision. Again, though we must welcome the use of committees and councils for educational inquiries, which is becoming increasingly established, as an encouraging sign that means are being sought to voice and maintain the authority of the tradition of culture in educational questions, yet the composition of such committees must be scrutinised with the greatest care. Such bodies, in my view, should exercise great authority, but this authority will only be a source of danger if it puts the power to modify our whole national culture into the hands of those who, whatever their distinction as administrators, or psychologists, or teachers, are without a synoptic vision of that culture. The development of isolated fields of knowledge has, I believe, no result more dangerous than the creation of specialist experts in education itself. It should be a humbling thought that there have been very few even moderately good books on education, and only one great one, and that it required the greatest of all philosophers to produce that one.

The expansion of the group concerned with one or other aspect of education does not, therefore, imply a strengthening of its power, but rather a weakening. Its diffused interests, its heterogeneity, and the increasing specialism of its members constitute a threat to its proper authority, and the knowledge that this authority has in the past been misused as a purely conservative force does not appreciably diminish the necessity for its proper use to-day as the only appropriate means of defining the limitations of liberty concerning the content and ideals of education. Such authority is especially necessary when we are faced with the danger that in an effort to create a common or democratic culture, standards may be submerged by too great

reverence for the opinions of majorities in matters, such as morals or æsthetics, where they are not valid. Our educational institutions also, in a rapidly changing environment, are subject to constant pressure to adjust themselves to what are ambiguously called " the needs of society ". Thus the " needs of society " are sometimes held to demand that Spanish rather than Greek should be the fourth language in Grammar schools, or that a chair of plastics-technology is a more proper part of a modern university than one of classical archæology. The discussion of the proper meaning that should be attached to such phrases as " relatedness to life ", or " the needs of society " in educational thought would take us too far from our central topic, but in my view it cannot be too clearly realised that the only check upon such pressure, which, of course, sometimes brings about necessary changes in the schools, is a lively, informed, and articulate concern on the part of the clerisy, working through advisory panels, examining bodies and the like. No confusion in educational thought is more serious than that which sees in the need of society simply a response to economic and social forces and fails to interpret them also in a moral and spiritual sense.

We can see an example of the indifference and impotence of academic opinion in the contemporary attacks upon external examinations. The subject may seem a very narrow and specialised one, unworthy of notice in a general survey. Yet I believe that more important principles are involved than is usually realised. Hitherto it has been held that all pupils in grammar schools should attempt to reach a common minimum of attainment in certain groups of subjects. The school certificate, imperfect though it is, is in fact laying down a criterion of general education for the boy or girl of certain intelligence, and its use for university entrance added authority to this view. With the abolition of the school certificate such an agreed core would disappear. For a number of years, perhaps for many years, the curriculum may remain without very radical change. Common agreement among teachers, habit, the influence of the inspectorate will maintain its integrity. But will it not, through the disappearance in this particular field of general academic authority expressed through examining boards, disintegrate in time, so that we shall be in danger of

losing all idea of an obligatory common basis of culture apart from the bare essentials of literacy? It may be that this result will not follow; it may be that the freedom from an external examination will be for the curriculum a legitimate and healthy freedom. The point that I wish to make is that a change so radical that may have profound results on the whole of higher education should occur with little thought and less comment at the higher academic levels, and that the body concerned with this change should include very many who, while being included in the term educationalists, are concerned with aspects of education quite remote from the proper core of knowedge for supernormal children of fifteen.

I believe, then, that as regards the content of education with all that this implies—the maintenance of a living culture, the proper adjustment of curriculum to contemporary economic and social changes, and the embodiment of new psychological discoveries—the only competent bodies are not composed mainly of administrators, qua administrators, nor of those who are expert in special areas of the educational field, but of those who may be supposed to have explored the really fundamental issues involved. These are to be found in the higher academic groups. The problems of liberty and authority in education impose on these a grave responsibility that there are signs that they are unwilling to assume; a responsibility to make themselves knowledgeable and concerned over general questions of educational policy; to speak with the authority that comes from an awareness of the values of a culture whose inheritors they are, and whose boundaries it is their highest function to extend. It is for them to create an authority that is strong, yet which never crystallizes into an inelastic orthodoxy.

If the ultimate authority as regards the intellectual aspects of education must be the consensus of informed academic opinion expressing itself through a new clerisy, what are we to say of the moral and religious aspects? It would, of course, be quite wrong to make a definite division between the cultural and the moral elements in education: at every point the two overlap. Yet it is true that in practice there is a difference in the readiness with which we are prepared to accept a compulsion to teach all boys arithmetic and one to teach them all divinity, and, indeed, such a

difference is legally recognised by the right given to parents to withdraw their children from religious teaching and not from that of other subjects. I have already touched on some of the questions ultimately involved. It is an essential part of education to inculcate certain moral attitudes: so much is scarcely ever seriously denied. Very many thinkers would indeed maintain that its chief aim, to which all activities must be subordinated, is the creation of goodness. But there will be deep divergeness if we attempt to state which principles of moral experience are sufficiently agreed as to form a basis for teaching, and still greater controversy as to how far such moral teaching must have a religious basis. It will be generally agreed that society working through all its educational agencies, official and unofficial, has the right to demand that its schools shall teach its children, for example, that lying and stealing are wrong; over the question as to whether such moral behaviour shall be related to the character of Jesus there will be less agreement; and a demand that all schools should teach that Jesus was the son of God would be regarded as a grave infringement of proper liberty. We are here faced with a genuine dilemma which arises from the whole character of modern society, and which is seen in its most simple and acute form in the schools. The difficulty is one to which I have already drawn attention. If we believe that we know the nature of the Good then surely it is our most pressing educational obligation to indoctrinate others with that knowledge. Yet it is precisely for that view, shared of necessity to some extent by any educator, that naïf and superficial thinkers accuse Plato of being a Fascist before his time. And there is this justification for their view, that our own society has agreed that over the areas of experience covered by morality and religion there shall be the widest possible tolerance.

Nevertheless, the difficulty remains. In particular it may be questioned how far the basic principles of social behaviour that all are agreed must be enforced by the educational process rest upon religious beliefs. From 1870 until 1944 the State in its control over the schools took the view that the two were quite distinct, so that schools were free to give religious teaching or not as they thought fit, and that if given such religious teaching must be free of dogmatic elements, though the difficulties of such

a position were left discreetly unclarified. The controversies of 1870 and of 1902 showed how deeply the questions of the religious background of education affected the national life. In the Education Act of 1944, however, state-aided schools are obliged to include religious worship and religious teaching in the education they provide, though tolerance is preserved by the fact that such teaching must be undenominational in character, and freedom by the right of withdrawal by a parent. The Act is thus trying to overcome the moral dangers of the secularisation of education which A. E. Taylor summarised in a passage which is worth quoting at length: "It may quite well be that the future philosophical student of history will yet find the most significant and disquieting of all the social changes of the 'Victorian Age' to be the combination of universal state-enforced primary education with the transference of the work of the teacher to the hands of the layman under no effective ecclesiastical or theological control. The effect of this successful laicisation of education has inevitably been to raise the immediate practical question whether moral conduct, the direction of life, does not form a self-contained domain, and ethics a wholly autonomous science, neither requiring support or completion from religion, nor affording rational ground for religious convictions of any kind. The gravity of this practical issue can hardly be exaggerated. Something more momentous than even our national existence is at stake; the question is that of an ideal of life for the whole of future humanity. It is idle to hope, as some of our contemporaries perhaps are hoping, that the secularisation of education may at least leave religion in being as a graceful and desirable embellishment of life for the exceptionally sensitive and imaginative souls. It is of the very nature of a living religion to claim the supreme direction of effort and action. If the claim is disallowed, religion itself ceases to be real; if it is allowed, it is idle to dispute the right of religion to be made the foundation of education. A wrong answer to the question about the relations of morality and religion, once generally accepted, is certain sooner or later, to be made the foundation of an educational policy, and adoption of a radically vicious educational policy means shipwreck for the spiritual future of mankind. (A. E. Taylor: The Faith of a Moralist.)

It is not my purpose here to discuss the soundness of this argument, but rather to draw attention to its central difficulty. Where are we to look to-day for the "effective ecclesiastical or theological control" of which Taylor speaks? What authority is there in our society that those engaged in education will recognise as competent to decide the character of religious teaching at various levels? The answer is: none at all. The disintegration of common beliefs which Professor Emmet in "The Nature of Metaphysical Thinking" sees even at the intellectual level, has certainly taken place so radically in matters of religion that it is useless to expect in contemporary education that coherence of belief that I have urged as a necessity in the intellectual field. This is a characteristic of our age and our society, and its discussion would take us far beyond my subject. It is the phenomenon recognised by writers as far apart in approach as Mr. Eliot and Professor Mannheim, and which leads the former to a deep pessimism concerning the future of our civilisation. I must content myself with the observations of a practising teacher on the problem. First, is its existence as disturbing as it sometimes appears? The absence of a recognised authority over certain fields of life is simply the price we pay for tolerance. It may be that the whole experiment of religious tolerance is mistaken and doomed to perish in a general disintegration of standards. If we believe this then we must declare ourselves as honestly intolerant, and be prepared to define the authority that we would be prepared to accept. We cannot have it both ways, speaking wistfully of the need for spiritual authority and at the same time hoping to reap the virtues of toughened individual consciences that should be produced by a greater freedom in these fields. Secondly, we must ask if the disintegration is as deep as we sometimes imagine. If we seek new ways to formulate them it may well be that there are wider areas than we are prone to believe where there is still agreement, and which can be safely made the basis for moral education and legitimate indoctrination. Finally, we must not make the mistake of confusing tolerance with indifference. It is not only right but necessary for teachers with strong moral and religious beliefs to state them. Such freedom must be subject to limits, and it may be objected that I have stated that there is no

relevant authority to pronounce upon these matters. I would contend, however, that while no single authority can pronounce positively, a number of educational authorities have the right to lay down the limits beyond which the individual should not go in moral or religious indoctrination. Such questions are, I believe, best solved individually and on the merits of each case. It is an error, into which we too easily fall, to despair if we cannot with complete generality lay down rules to govern every problem of belief in education. The whole assumption of a free society is that individuals are on the whole sensible, and it is on this sense expressing itself in individual decisions that we must rely for the limitation of illegitimate liberty in the moral and religious spheres. Nor do I believe that divergences in religious teaching necessarily bring in their train the evils that Taylor anticipated, provided that the variations rest on genuine and deeply held conviction, though on this point certainty is, of course, impossible.

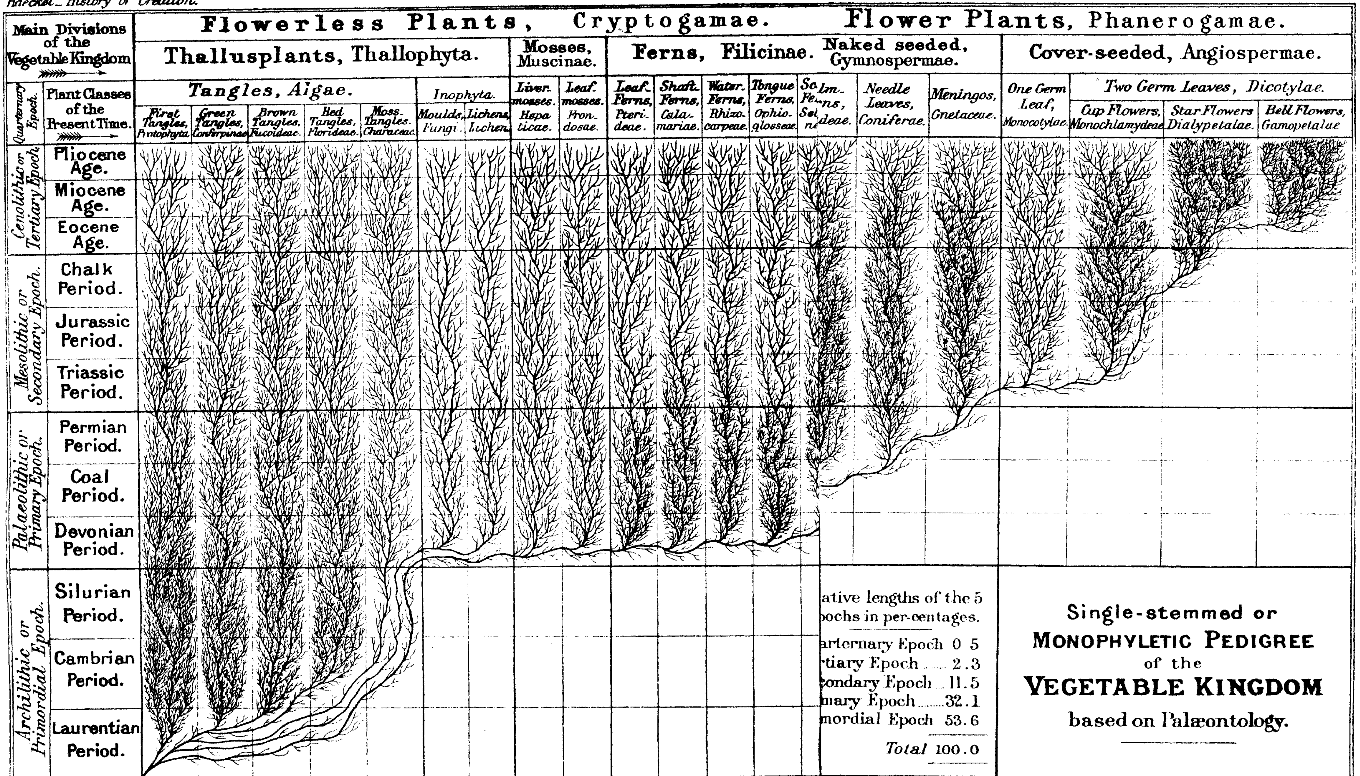
But what many will call a dangerous libertarianism in the religious field (and whether dangerous or not I contend only that it is unavoidable) may be stabilised by that genuine authority in our intellectual life that I have already stressed. The two fields are in the closest degree inter-related : a necessary freedom in one must be balanced by a determination in the other to maintain with all possible resolution that not all views are equally true, nor all pursuits equally valuable. Such an emphasis on the value of the educated judgement as opposed to that overemphasis on the personal opinion whatever its weight that is one of the dangers of democracy, such a new note of conviction and re-affirmation of authority in our academic life, would have a bracing effect on all our activities, and not least in the moral sphere. It is the function of inspectors, of administrators, of the schools and perhaps most of all, of the universities to supply it. Upon them rests the responsibility for maintaining the standards of Western culture through an era of immense social change, and of ensuring that, as wider social groups come into their inheritance of that culture, it has not been mortgaged in the name of liberty.

Process and Record: Aspects of Botanical Science.

By C. W. Wardlaw.

It is surely a strange and surprising thing that Morphology—the study of Form in plants and animals—which Charles Darwin regarded as "the most interesting department of natural history", indeed, "its very soul", to-day stands in danger of suffering eclipse by failing to appeal to the younger generation of botanists. Without some knowledge of the external form and internal structure of plants there can be no approach to *the* most comprehensive theme in Biology—the process known as Evolution or Descent with Modification. What the botanist knows of this process is necessarily based on the comparative study of plants. It is therefore a matter for surprise that, among botanists, interest in this branch of the science has undergone a marked decline in recent decades. Not only that, but many of the major conclusions regarding the evolution of plants have been seriously challenged. What the botanists of the Darwinian and post-Darwinian period tried to do was to show the relationship of the various classes of plants during the course of their descent from common ancestors. They tried to reconstruct the family or genealogical tree of plant life and, indeed, they considered that their efforts had met with a very considerable measure of success. But to-day many botanists see the matter in a different light. It has been asserted that the search for common ancestors is a hopeless quest, the genealogical tree an illusory vision. But if the subject possesses the merit which Darwin claimed for it, there is clearly need for inquiry into the present state of affairs. The record of plant development during remote past ages, together with the comparative study of living forms, would appear to provide a theme of perennial interest to men of philosophic mind. Nevertheless, it has been said that the whole of this branch of botany—the investigation of the phylogeny of plants—leaves the majority of the younger botanists cold.

Some contemporary botanists, no longer attracted by comparative morphology, and even holding the pronouncements of the professed phylogenist in contempt, see a promising and little-worked field in the study of the organisation which becomes apparent during the *process of development* of the individual; in other words in the study of *Morphogenesis*. The aim of this


Main Divisions of the Vegetable Kingdom
Flowerless Plants, Cryptogamae.
Flower Plants, Phanerogamae.
Thallusplants, Thallophyta.
Mosses, Muscinae.
Ferns, Filicinae.
Naked seeded, Gymnospermae.
Cover-seeded, Angiospermae.
Quarternary Epoch.
Plant Classes of the Present Time.
Tangles, Algae.
Inophyta.
Liver mosses. Hepaticae.
Leaf mosses. Frondosae.
Leaf Ferns, Pterideae.
Shaft Ferns, Calamariae.
Water Ferns, Rhizocarpeae.
Tongue Ferns, Ophioglosseae.
Needle Leaves, Coniferae.
Meningos, Gnetaceae.
One Germ Leaf, Monocotylae.
Two Germ Leaves, Dicotylae.
First Tangles, Protophyta.
Green Tangles, Confervinae.
Brown Tangles, Fucoideae.
Red Tangles, Florideae.
Moss Tangles. Characeae.
Moulds, Fungi.
Lichens, Lichen.
Cup Flowers, Monochlamydeae.
Star Flowers Dialypetalae.
Bell Flowers, Gamopetalae
Cenolithic or Tertiary Epoch.
Pliocene Age.
Miocene Age.
Eocene Age.
Mesolithic or Secondary Epoch.
Chalk Period.
Jurassic Period.
Triassic Period.
Palaeolithic or Primary Epoch.
Permian Period.
Coal Period.
Devonian Period.
Archilithic or Primordial Epoch.
Silurian Period.
Cambrian Period.
Laurentian Period.
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Single-stemmed or
MONOPHYLETIC PEDIGREE
of the
VEGETABLE KINGDOM
based on Palæontology.

study is to explain, in terms of mathematics, physics and chemistry, how, at each stage in the development of the individual, the distinctive form comes to be what it is. In other words it attempts to answer the question : How, during the growth of a plant, is the characteristic form or succession of forms, produced, and what are the factors involved ?

It now seems evident that the post-Darwinian botanist, intent on comparative studies with a view to the construction of a phylogenetic system, or " family tree ", had an insufficient knowledge of the process of development. But the contemporary student, in attempting to make good that deficiency, is liable to fall into a not dissimilar neglect of the historical aspect. Both studies have distinctive and important contributions to make to the common theme. Each is related to the other though the nature of that relationship may often be obscure. In brief, the wider vision requires consideration of both Morphogenesis and Phylogenesis—i.e. of both Process and Record. My theme on this occasion, then, is to show how our views on these two aspects have developed, and how they may be related to each other.

2. *Botanical Trends during the Nineteenth Century.*

The two important trends in botanical science with which we are concerned here can be discerned during the middle decades of the Nineteenth Century. One of these related to the process of development both in the lower and higher plants, the other to the natural classification of plants and, after Darwin, to their genealogical relationships. Let us briefly consider the distinctive features of these two aspects.

3. *Problems of Development.*

It is little more than one hundred years ago since the German botanist, Schleiden, scornful of the contemporary state of botanical science, trenchantly preached a new gospel—that the high road to discovery lay in the study of the development of plants. A period of remarkable progress ensued : Von Mohl restored the study of anatomy while Naegeli, by addressing himself to the questions of how cells—the units of plant construction—are formed in growing vegetative organs, founded and elaborated the theory of cell formation. In particular,

he showed that the processes are closely comparable in the Lower Cryptogams and in vascular plants, including Pteridophytes and Flowering Plants. It thus became possible to give a coherent account of the anatomical development of tissues and organs from the unicellular zygote, or fertilised egg, to the highly differentiated, multicellular adult of complicated form and structure. In Naegeli's view, the history of development was not merely to be regarded as one of various ways of investigating plant form but as being indentical with the investigation of organic nature. He proceeded from an examination of simple organisms such as the Algae to the more complex types of organisation seen in Ferns and Flowering Plants. In these studies the initiation and development of organs were referred back to cell formation during growth at apical growing points. These observations, which were amplified by Hofmeister and others particularly for the Higher Cryptogams, served as a basis for many subsequent developments in botanical science.

Prompted by the writing of Schleiden, Wilhelm Hofmeister devoted himself to a detailed study of what was then an almost completely unexplored field, namely, the reproduction and embryology of Bryophytes, Pteridophytes and Seed Plants. In fact he worked out what we now describe as the life history of these plants. He showed that they all share a common life-cycle, characterised by the same critical events, and by a recurrent alternation of generations. (Higher Cryptogamia, 1862). But as his work progressed it ceased to be merely descriptive. It was not enough for him to observe that during the development of a particular species a regular succession of characteristic changes in form and structure took place. He constantly inquired: How does the observed form come to be? To what processes of growth can the observed structural developments be related? What internal and external factors determine specific structural organisation? The substance of such investigations he described in 1868 as the *General Morphology of Growing Things.* In short, he tried to use mechanico-physical ideas in his morphological studies and, together with the data of physiological experiments, to derive generalisations therefrom.

It might be thought that as a result of Hofmeister's investigations and his critical search for the relationship between

physiological activity and the assumption of specific form or pattern, botanical science had at length been established on a broad and sure foundation—one in which morphology and physiology were seen to be inseparable aspects of the same theme. It might further be anticipated that these investigations of the process of development would have made rapid progress in the hands of his successors. This, however, was not the case as we shall presently see.

4. *Evolution and the Phylogenists.*

In the development of botanical science the initial phase of collecting, cataloguing and grouping of plants (usually on an arbitrary basis) was followed by attempts to construct *natural systems* of classification. The aim of these systems was to indicate the gradations of natural affinity among organisms. Plants which bore a general resemblance to each other, and which shared a number of the more important characters in common, were held to belong to the same circle of affinity and, by implication, shared the same hereditary constitution. Thus groups of genera were associated together into families, or natural orders, and these, as also the larger subdivisions, became defined with a considerable degree of certainty and precision, just as, at an earlier stage, Linnaeus had fixed the boundaries of genera and species. By the middle of the Nineteenth Century these natural systems had reached a high degree of completeness. It may perhaps strike the modern biologist as not a little strange that the founders of these natural classifications were nevertheless adherents of the dogma of the Fixity of Species. With the publication of Darwin's Origin of Species in 1859, these natural classifications were thus at hand, ready for use in the construction of phylogenetic systems, i.e. systems showing the *natural affinities, or genetical relationships, of organisms during descent.*

In the period—sometimes described as the Phyletic Period—that followed Darwin's enunciation of the Theory of Descent with Modification, the details of the form and structure of living plants, together with such facts as could be gleaned from the fossil record, were regarded chiefly as providing materials for comparative studies and for the construction of phylogenetic systems; in everyday language, for reconstructing the "family"

or "genealogical tree". There was, in brief, a very marked swing away from the causal outlook which had characterised Hofmeister's later studies. Botanists were no longer preoccupied with the question: How does the observed form come to be, in terms of physical, physiological and other factors? but, What family relationship is indicated by the observed form or structure and what light does this information throw on *the course of evolution*? The *general* or *causal morphology* of Hofmeister was, in fact, displaced by the *special comparative morphology* of the students of evolution. Now, it is evident that there can be no study or interpretation of evolution in plants or animals without having recourse to comparative morphology. Evidence of evolution is seen in the extensive changes in the form and structure of plants during the passage of geological time and in the diversity of form and structure in living plants. As a result of the studies which were undertaken in the phyletic interest, our knowledge of the range of plant structure was enormously extended. A vast new realm, so worthy of exploration, must indeed have opened out before the comparative morphologist. In particular, the Ferns and their allies, the progenitors of which reach back to the Upper Silurian and Early Devonian Periods, were found, more than any other class of plants, to provide the raw materials for the study of evolution. Comparative or Formal Morphology, now provided with an integrating thesis of the most far-reaching possibilities and interest, had come into its own. In these studies, the conclusions from detailed and comprehensive investigations of the structure of living organisms were checked against the evidence of the fossil record; and, bit by bit, a coherent if still speculative and necessarily incomplete account of the genetical relation of plants during descent was sketched.

The sweeping success of Darwin's views among biologists is understandable. It would be surprising had it been otherwise. The raw materials were at hand in the more or less complete natural classifications which had been devised in the previous fifty years. The dogma of the Fixity of Species, so long and tenaciously held, was ripe for destruction. Darwin's full and masterly outline of the theory of *Descent with Modification* must evidently have provided a key which would not only unlock

many doors but would enhance the value of the treasure that lay within awaiting discovery. To the student of phylogeny, it must surely have appeared that to whatever group of plants his researches were directed, fruitful results were assured. Since Nature was a unity, all findings were bound to "fit in" somewhere; all destined to contribute in some measure to the wonderful edifice of evolutionary theory. The highroad to achievement lay in the study of comparative morphology, which, in fact, became a restricted and well defined discipline. The facts of development and the characteristic features of the adult, as ascertained by the observation of form and structure, were used in the formulation of what we should to-day regard as purely morphological concepts, physiological and causal aspects receiving at best little more than passing attention. The relation between form and function, which Sachs and later Goebel described as Organography, was, of course, of importance to those who maintained the Darwinian position and assumed the all-pervasiveness of adaption in plant life. On the other hand, the factors relating to the formation of organs and the differentiation of tissue systems for the most part remained unexplored.

5. *Decline of Comparative Morphology.*

Several decades passed before the methods or conclusions of the phyletic morphologists were seriously challenged. But gradually doubts began to accumulate. A bad feature of the phyletic period was that plant morphology and physiology were largely pursued as separate disciplines. Morphologists and anatomists, moreover, tended to resort to facile, pseudo-physiological assumptions: these were typically not tested by experiment. Then other difficulties became evident. We have seen that both natural and phylogenetic classifications necessarily rested on a basis of comparison. Indeed, the search for criteria of comparison was a major part of the morphologist's task. Similarity of form and structure in the principal organs and tissues was accepted as an indication of genetic affinity or blood relationship; in other words, organisms which showed the same underlying form and structure, and which passed through comparable stages during development, were held to be

related and to share a common origin. But, as the survey widened, it was realised that similar structural features might occur in plants which, as judged by other criteria, were in no way related. In short, it became evident that *parallel* or *homoplastic* development was of frequent occurrence both in the plant and animal kingdoms. As information of this kind accumulated, faith in the validity of the previously accepted criteria of comparison declined. This eventually led to the view that instead of there having been one family tree, or one main line of descent, as had generally been assumed by biologists of the Darwinian period, it was probable that there had been several, even many, parallel lines of descent from primitive ancestors. The family tree, in fact, had become a thicket. Later, because of the recurring difficulty of linking one main group of plants with another by means of common ancestors, the ultracautious and the pessimistic were to hold that the "genealogical tree" had been reduced to a bundle of sticks; and that the search for common ancestors was a hopeless quest. (As a striking example of the completeness with which the monophyletic system was envisaged, the figure from Haeckel's *History of Creation* is here reproduced.)

A protagonist of the extreme polyphyletic view, Church (1919) asserted that land vegetation developed from transmigrant algæ which had already reached a high degree of differentiation and elaboration in the sea. The chief phyla or families of land plants already had marine precursors before the period of the transmigration. Church even suggested that Pteridophyte classes such as the Lycopods and Ferns represent independent lines which have run distinct, though in many respects parallel courses from the earliest times, even perhaps from the original flagellate ancestors. So, too, with other classes of plants. In this extreme view the monophyletic genealogical tree would be replaced by a series of parallel lines of descent, these arising from a group of unicellular organisms of great antiquity.

Briefly summarised, this is the situation: we do not know how the Mosses and Liverworts originated from more primitive organisms such as the Algæ, or how, in turn, to relate the Mosses and Liverworts to the Ferns and their allies, which represent the next level in structural organisation; we do not know how

to link the Pteridophytes with the Gymnosperms, or the latter with the Flowering Plants. And finally, among Flowering Plants, we do not know, at least, with any precision or assurance, how one great cohort or natural group is related to another. Nevertheless, the broad fact of evolutionary change throughout geological time is not in doubt. Moreover, within individual major classes, such as the Ferns, of which we have knowledge going back to Carboniferous and Devonian times, there is unmistakable evidence of a broad and sustained progressive development from ancient and primitive to modern and derivative types. In brief, whereas we can indicate the course of evolution in a single phyletic line, i.e. a single branch of the hypothetical genealogical tree, difficulties arise when we try to relate this branch to neighbouring branches and to the main trunk. In this connection D'Arcy Thompson (1942) has pointed out that a " principle of discontinuity " appears to be inherent in all our classifications. Within any natural group there may be evidence of the continuous process of evolution, but between groups considered to be allied, more often than not discontinuities are evident. Yet that a natural affinity is involved seems scarcely to be doubted. As D'Arcy Thompson says, " there are gaps between the groups but we can see, so to speak, across the gap ". But, in other instances, " the breach is so wide that we cannot see across the intervening gap at all". Unless much new fossil evidence comes to light, it now seems that the bridging of the several gaps—if they can be bridged—is unlikely to result from the methods of comparative morphology alone.

6. *Renewed Study of Process of Development.*

We may now inquire what precisely is meant by " process of development " which seems to provide the contemporary botanist with opportunities for fruitful investigations. I understand it to mean the investigation of the factors which determine the characteristic external form and internal structure of an organism, and the integrated " wholeness ", or organisation, which it shows throughout development. Eventually studies of process would also include a consideration of development in its wider evolutionary sense and of the forces which bring it

about. It will be seen that the aim of those who would investigate the process of development is very similar to that which inspired Hofmeister's *General Morphology of Growing Things* nearly eighty years ago. No justification is needed for these studies : as Professor Lang pointed out many years ago, even if the phyletic history of plants were before us in full, the problems of causal morphology would still remain ; while it is evident that the relevant investigations are of the very essence of scientific inquiry.

In studies of Flowering Plants and Ferns, particular consideration will be given to the factors which determine the leafy-shoot type of organisation, the development and shape of leaves, buds, hairs and scales, roots, and reproductive organs, and the differentiation of the more or less complicated tissue systems within. These considerations prompt yet a further inquiry, namely : Should these researches be pursued to a successful conclusion, to what further use can the data be put ? To this question we shall return later.

If the advances which have been and are now being made in the application of physics and mathematics to biology can be sustained ; and if the data of certain aspects of physiology and genetics can be integrated with those of experimental morphology, substantial progress in the study of development may be anticipated. Already, in such notable works as Professor D'Arcy Thompson's *Growth and Form*, we find numerous fascinating examples which show how a knowledge of the laws of mathematics and physics contribute to an understanding of the development of form and structure in plants and animals. " Cell and tissue, shell and bone, leaf and flower, are so many portions of matter, and it is in obedience to the laws of physics that their particles have been moved, moulded and conformed " (p.10). True, in a majority of the instances cited, we still await experimental proof : nevertheless there seems to be little doubt that many aspects of form and structure—which, as we have seen, are of great interest and value to the comparative morphologist—are largely explicable in terms of physical and mathematical laws.

From another angle evidence is accumulating that certain morphogenetic processes are due to the action of specific biochemical agents, i.e. particular metabolites, or substances used

in growth. Biochemistry, in fact, is everywhere becoming of increasing importance in botanical investigations. As Dr. Joseph Needham has said (in *Biochemistry and Morphogenesis*) " Form is not the perquisite of the morphologist. It exists as the essential characteristic of the whole realm of organic chemistry. . . there can be no sharp distinction between morphology and biochemistry ". In biochemistry, as in biology, we are concerned with two basic considerations, energy and organisation. Nevertheless, it is no easy matter to show precisely how biochemistry and morphology are related. We now know that a close and possibly obligate relationship exists between the presence of certain activating substances—morphogenetic hormones—and the formation and differentiation of organs and tissue systems. But to explain why an organ or tissue acquires its characteristic configuration because a certain chemical substance is present, is no easy matter. It seems probable that even the simplest biological form or pattern is due to the action of several factors, including the biochemical factor. In the exploration of this aspect we have still a long way to go but a beginning has been made.

It is also pertinent to note that recent investigations by plant physiologists of particular phenomena such as photoperiodism—the effect of exposure of growing plants to different periods of light and darkness—are adding to our knowledge of the factors which determine form and structure; while their studies of growth have an essential place in the investigations under consideration.

7. *Genes and Development.*

All the foregoing considerations, however, only take us part of the way. Every living organism possesses a number of more or less well defined external and internal features, or characters, which become apparent during development; such as the size and shape of the leaf, the colour and construction of the flower, and so on. These characters are specific for each individual species and are heritable. Fundamentally they are controlled by determining agents or factors—the genes—which are located in the cell nucleus. There are good reasons for the view that these genes are particulate in nature, that they occupy definite positions

in the chromosomes, and that they retain their individuality throughout the cycle of development of the individual plant or animal. For us, the basic questions are these: How do genes operate during morphogenetic processes? How and when does each gene work so as to contribute to the orderly development characteristic of any particular species? Such questions have only recently begun to receive attention. Indeed, a relatively new branch of biological science, described as Physiological Genetics, is beginning to gain adherents. The methods of this branch of biology would, as I understand the situation, include the physiological and morphological investigation, during development, of plant materials of known genetical constitution. It would, in fact, be the meeting place of the geneticist, the biochemist, the physiologist, the mathematician, the physicist, and the morphologist—in short, it would represent a desirable return to the central aims of Botanical Science. So far, the instances that permit of a co-ordination of the data of these several branches are few in number. At present very little is known about the nature of the gene and its primary action, how and where it exerts its effect, whether it affects only one step in the developmental process, whether it affects a succession of steps, or whether it is involved in every aspect of development. In broad outline, the aim of Physiological Genetics will be nothing less than to establish the chain of causation between particular genes and the ultimate appearance of characters in the adult organism. In practice this will require comprehensive studies of the action of biochemical substances known to be gene-controlled, together with the other factors which affect morphogenetic processes. These investigations cannot fail to prove of considerable complexity. Nevertheless, much may be achieved in the course of the next few decades.

As to the fundamental nature of the gene, and the related problem of genic mutation, suggestions of a most exciting and far-reaching kind have been made. It is thought that the gene may consist of a very large organic molecule—it has been described as an aperiodic solid—and that when a genic mutation takes place, either spontaneously or by induction, the change is a quantum change of the kind studied by atomic physicists.

As a result of mutation the properties and biochemical action of the gene may be modified to a greater or less extent, and this may be reflected in changes in the eventual form and structure of the adult.

8. *Towards a Synthesis.*

Perhaps at this point it may be permissible to speculate on possible developments in the next few decades, bearing in mind the fallibility of all such speculation and the probability that the performance is likely to fall far short of the expectation. If it can be shown that evolutionary changes, or some aspects of evolutionary change, are due to the cumulative effect of genic mutation in conjunction with the selective action of the environment, and if the rôle of genes in morphogenetic processes can be more adequately explored, a comprehensive biological synthesis should become possible. Here it is proper to note that some of the hereditary factors may be located in the cytoplasm. But, generally, the hereditary constitution of a species, itself a small fragment of the evolutionary picture, is conceived as being sub-divisible into genes. These genes, large organic molecules, of which the composition and structure may one day be known are involved in all developmental processes; they find expression in chemical reactions which, together with the other factors at work during growth, directly or indirectly determine form and structure, and culminate in the distinctive appearance of the adult. These large organic molecules are apparently subject to mutational changes of a kind that are of present interest to the organic chemist and molecular physicist, and may one day be more fully invest gated by them. If now, in a particular plant species, mutations appear or are induced in one or more genes or n the cytoplasm, modifications in the whole chain of reactions during development may result; and an adult configuration may be produced which differs in some respect from that of the original species. In a manner that is not possible in the present state of knowledge, it may eventually be possible to explain—or at least to give some approximate indication of—what is happening at critical stages during development. The basic assumption on which the biologist works is that all the characters which we see in plants can ultimately be referred back

to the hereditary constitution of the organism, to the action of mathematical and physical factors, and to factors in the environment. In practice it is impossible to separate the action of the genes from the action of the many other factors which also take part in determining the development of form and structure. Nevertheless, by observation and experiment, it may in time be possible to indicate more specifically the particular kinds of morphological development that result from the action of particular factors. Some aspects of form and structure, as we have seen, are due to mathematical and physical factors and, in a sense, are extrinsic to the hereditary or genetic constitution. But others, those which we regard as being gene-controlled, are inherent or intrinsic. Ultimately, it is the developments which are gene-controlled, or are controlled by the specific hereditary substance, that are of paramount interest to the student of evolution. Hence in the course of the next few decades—for Science, like Art, is long—it may be possible to indicate in broad outline the chain of causation which begins with the mutating gene and culminates in the appearance of new morphological characters in the adult mutant plants. Morphological studies of the parent and mutant forms would be an essential part of such investigations.

The comprehensive investigations which I have indicated would necessarily relate to plants now living. But if a clearer understanding of the factors that determine form and structure in living plants can be achieved, a fuller and more adequate interpretation of the developments indicated by the fossil record may become possible, though it can never be absolute. It may even be possible to fill in some of the numerous phyletic gaps: indeed, in some instances they may not prove to be gaps in the sense hitherto understood. How the new knowledge will affect our views on the process of evolution remains to be seen: the topic is clearly one of the greatest importance and interest to biologists.

Hyperbolic Navigational Charts.*

By NORMAN PYE.

Wartime operations have always run the risk of being hampered by darkness, fog, mist or clouds, and it was a triumph of radar to eliminate this handicap. That part of the wartime development of radar technique which has been applied to problems of marine and air navigation under any conditions of visibility probably represents radar's most important contribution to the arts of peace. Among the variety of newly-developed radio aids to navigation there is an important group using a method which has come to be known, for reasons that will become apparent, as the hyperbolic method. These are of special interest and value to marine and air navigators as affording an accurate means of position fixing and course determination when visual fixes, dead reckoning or astronomical observations are impossible. Their facilities are available, however, only if the navigator is equipped with the specially prepared charts appropriate to the system he is using. In speaking to-night on the subject of these hyperbolic navigational charts, my lecture will fall into three parts. First an outline of the principles of the navigational method and a summary of the systems to which the charts refer. The second part will be concerned with the cartographic problems and techniques involved in the preparation of the charts. In the last part of my paper there will be consideration of the use of hyperbolic navigational charts not only for navigation but also as aids to hydrographic, topographic and air survey.

All radar devices use the fact that electromagnetic radiation is propagated through the atmosphere (strictly a vacuum) at a constant speed of 186,200 miles per second, i.e. 1 mile in 5·37 microseconds or millionths of a second. The distance between two points may thus be determined by the time taken for short pulses of radio energy to travel between the two points. If we consider two radio stations *A* and *B* (Fig. 1) each transmitting a regular series of uniformly spaced radio pulses the signals may be thought of as analogous to the ripples that are

* The author wishes to acknowledge his thanks for Admiralty permission to base this paper on work with which he was concerned during service with the Hydrographic Department.

set up when two stones are thrown into a pool. The ripples, or in reality the radio waves, travel outwards from their origin at a uniform speed and in radiating outwards the two sets of waves overlap and intersect. A ship or aircraft at P will receive pulses from A a certain time after transmission, the time interval depending entirely on the distance between A and P; if v=the velocity of electromagnetic waves the time taken for a pulse to travel from A to P $(t_1)=AP/v$. If the pulse from A, the "master station", is picked up at the second or "slave" ground station situated at B, and this second station transmits its pulse at a definite time T after receiving the pulse from A, then counting as an origin for the time reference the time at which A transmits, it follows that the ship or aircraft will receive the pulse from B after a time (t_2) equal to the sum of the time of travel from A to B (AB/v), such delay as may be introduced* between reception of A pulse at B and the transmission from B $(=T)$ and the time of travel from B to P (BP/v), i.e. $t_2=AB/v+T+BP/v$. Equipment in the ship or aircraft enables the navigator to measure rapidly the time difference between the arrival of the synchronised A and B pulses, i.e. the quantity t_2-t_1 which equals $AB/v+T+PB/v-AP/v$. The quantities AB (the base line separation between the stations) and v are known constants and the equipment at the ground stations enables T to be kept constant also—at any rate to limits of less than 0·1 of a microsecond. Therefore if t_2-t_1 is known $PB-AP$ will also be known. The receiving equipment does not measure the time taken for a pulse to reach it from either station, but the *difference* in time between the arrival of pulses from A and those from B. The locus of a point having a constant difference in distance from two fixed points is a hyperbola, so one measured time difference will fix the position

* If both master and slave pulses were transmitted simultaneously they would be received simultaneously on the perpendicular bisector of the base line and the corresponding time difference would be zero. On either side of the centre line the pulse from the nearer station would arrive first. In practice the master and slave pulses are not transmitted simultaneously. Each slave is delayed by a carefully controlled amount so that the corresponding master pulse is always received first. This eliminates any ambiguity in identifying the pulses and gives time differences which increase continually from a minimum at the slave station to a maximum at the master.

of the observer as somewhere along a hyperbola having the two fixed transmitters as foci, i.e. will provide a position line with reference to the transmitting stations. By introducing a third slave station C working in synchronised conjunction with A a second family of hyperbolas can be obtained, this time with AC as foci and intersecting the first set. By measuring the time difference between the arrival of the A and C pulses the navigator can fix his position along one of the second set of hyperbolas. It follows clearly that the complete fix is given as the point of intersection of the two position lines. To overcome any ambiguity from a double cut of the curves a fourth slave station D may be provided. A system of this kind virtually lays down a radio mesh of intersecting hyperbolic lines, known as a lattice, over a selected area of the earth's surface ; an observer can obtain a fix relative to this arbitrary system of curves at any point within range of the transmitters, provided he is equipped with a suitable receiver and also with a key to the lattice mesh in the form of a topographical map or hydrographical chart containing the ground positions of the hyperbolas.

Fundamentally there are two possible methods of distance determination by transit time differences—the impulse method and the phase method. To date the pulse system has been embodied in the Gee and Loran (LOng RANge) equipments. The phase technique adopted in the Decca Navigator* employs a continuous wave radiation and achieves its measurement of time differences by comparison of the phase differences of the waves at the point of reception. Although different in their technique, both employ the principle of measuring the difference in time for radio waves to travel from pairs of synchronised transmitters to produce a fixed hyperbolic space pattern of

* A more recent development, not yet fully tested, but with expected service range of 1,500 miles over water is the Post Office Position Indicator (P.O.P.I., or " Pop-eye " as it seems inevitably to be !) is also based on comparison of the phase of signals radiated from two narrowly separated beacons one-third of a mile apart. The lines of constant phase difference again consists of a family of hyperbolas with the aerials as foci, but owing to the smallness of the base the hyperbolas become substantially straight lines at a few wavelengths from the stations, i.e. at about 2 miles. Therefore lines of constant phase difference are great circle lines radiating from the beacons and could be used as track guides for great circle navigation. (1) and (5).

constant time differences. Any full account of the equipments would take us unnecessarily far into electronics, yet there are certain basic points, either necessary to permit the commencement of plotting of hyperbolas on map or chart, or which have cartographic expression, that demand some appreciation of the working of the systems for them to be understood.

Decca. Phase differences in the waves received from the fixed transmitters will be nil, i.e. the waves are in phase, along the perpendicular bisector of the base. At all points one-quarter of a wavelength nearer the master station *A* and therefore one-quarter wavelength further from slave *B*, there is a half wavelength difference ; another quarter wavelength nearer *A* there is one whole cycle difference and the two again come into phase. Each pair of stations gives rise to a series of confocal hyperbolas representing loci of equal phase-difference from the transmitters. The space between any two inphase hyperbolas is called a lane and the number of lanes obviously depends on the wavelength employed. If it were 1,500 metres the lanes would be 750 metres wide along the base line joining the transmitters, widening out away from the interstation line. On charts for use with the Decca navigator (Fig. 2) nine hyperbolas form with the base extension ten zones lettered *A*—*J* from the master end. Within each of these zones are 18, 24 or 30 lanes dependent on the wavelength employed. Zones between hyperbolas belonging to the master and red slave have 24 lanes numbered 0—23 and the lattice lines are printed in red. The curves produced by the master and green stations are printed in green and 18 lanes numbered 30—47 are contained in each zone. Similarly the curves produced by the master and purple stations are printed in purple and each of its ten zones contains 30 lanes numbered 50—79. This numbering and notation is the same as that registered on the receiver meters and enables the reading to be transferred immediately to the chart.

Gee and Loran. Since the velocity of the propagation of radio waves is about 983 feet per microsecond the time of transmission of pulses must be controlled to a few millionths of a second, and the resolving power of the receiving equipment must be equally good, if the method is to yield fixes of an

accuracy comparable to that of other methods of navigation. Time intervals of this brevity cannot be handled by mechanical contrivances and so an extremely rapid and accurate stop-watch—a cathode ray tube—is used. The essentials of this device are that in a glass tube a heated cathode emits a stream of negatively charged electrons which strike the glass screen forming the end of the tube. This screen has a fluorescent coating and the electron stream causes the fluorescent material to glow, producing a bright spot. By acting upon this stream of negative particles electrically the spot can be made to trace out a light pattern on the screen which bears a strict relationship to the electrical forces acting upon the beam. The simplest form of display used for the measurement of distances is as follows. Flanking the stream of electrons are two pairs of parallel and mutually perpendicular plates to which charges may be applied to create an electrostatic field. Differences in potential between the two vertical, or X, plates will deflect the beam horizontally; if variations in potential are applied in a sawtooth manner to these plates the light spot can be made to travel horizontally across the face of the tube at a constant speed, fly back rapidly and repeat the cycle. After-glow in the fluorescent material and a sufficiently high frequency will make the spot appear to be a continuous horizontal bright line. Similarly, by applying differences of potential to the horizontal, or Y, plates during receipt of a pulse, the electrons will be deflected vertically, producing a momentary spike at some point on the trace. Knowing the frequency of recurrence of the spot traversing the face of the tube, the length of time taken to traverse it once is also known, i.e. the line constitutes a time base along which time intervals can be measured. If circuits are designed to apply a potential to the Y deflecting plates, i.e. cause a vertical deflection of the spot at the instant the pulse from the master station A is received, and to apply other potentials at the instants pulses from the slaves are received, the distances between the leading edges of the master and slave pulse deflections measures the elapsed time between receipt of the pulses. It will be appreciated that the pulse recurrence frequency of the transmitted signals must be identical with the frequency of the time base to produce a steady picture.

Only if, between pulses from the same station, the spot has just time to run over its entire path and return to the same point, will the blip be repeated at this point in every recurrence interval and so appear as a stationary feature of the trace.

The factors concerning the Gee and Loran systems that determine the basic spacing and numbering of their hyperbolic position lines may now be considered. In the Gee system the frequency of sweep of the time base is 250 per second, i.e. the time for one sweep is 4,000 microseconds. Whole number calibration marks from which the tube is read are superimposed on the time base by an oscillatory circuit working at a frequency of 15,000 cycles per second. Thus one blip occurs every 66·66 microseconds, and this interval of time has been adopted as the unit of measurement, the Gee unit. Position lines on the map or chart must be determined so as to give values of whole Gee units and their decimal parts. The basic points necessary to permit plotting of the hyperbolas are the points of intersection with the base line joining the two transmitters, of each hyperbolic position line which bears a whole number, these numbers corresponding to the whole number calibration marks on the time base trace. The spacing in miles between these points can be calculated from the data above. The distance along the base line represented by one whole Gee unit will be that distance covered by a receiver, moving along this line, which will cause a change in the difference in time of arrival of the pulses from the two stations of 66·66 microseconds. Since a movement towards one station must at the same time remove the receiver by an equal amount from the station at the other end of the base, it follows that the separation of points giving a time difference of one Gee unit along the base line will be $66{\cdot}66/2 \times 1/5{\cdot}37$ (the speed of propagation of pulses is 1 mile in 5·37 microseconds)$=$approx. 6·2 statute miles or 10,000 metres. Theoretically the maximum number of calibration blips available on the trace could be $4{,}000/66{\cdot}66=60$, but part of the time of sweep of the time base is taken up in the period of fly back, with the result that only some 56 blips are visible. Since also the system is designed to operate with one master and two slave stations for the purpose of providing two sets of position lines, the maximum length of each base line will be

$56/2 \times 6{\cdot}2 = 174$ miles approx. In actual practice the length is usually not more than 80 miles, the shorter limitation being imposed by the effective range for the synchronising signals.

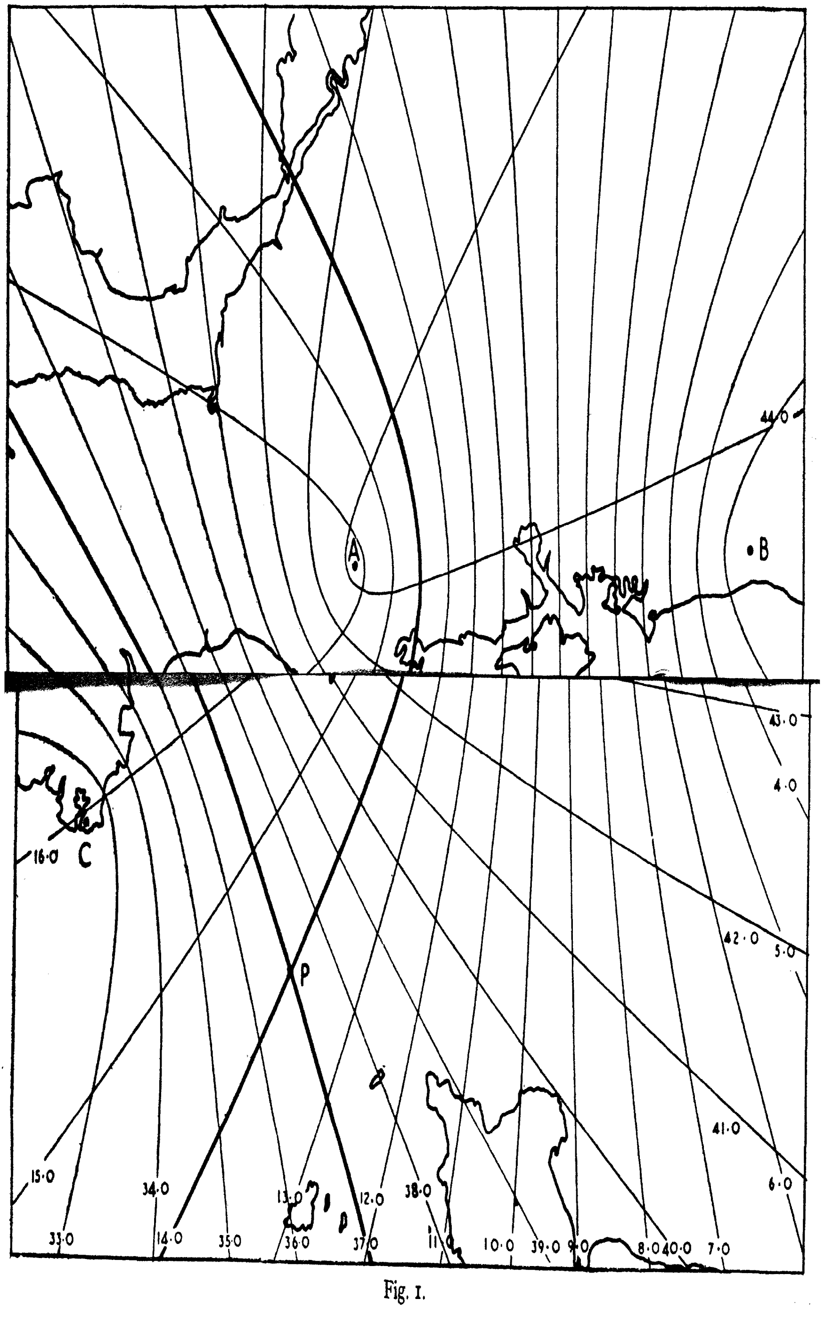
The numbering of the Gee lattice curves may be explained simply. In order that the pulses from the slave station *B* shall arrive at the observer later than those from the master station *A* no matter where the observer might be, a delay is imposed on the pulse from *B* such that, if the receiver is at *B*, the pulses will arrive at some stated number of whole Gee units later than the pulses from *A*. If the receiver is moved along the projection of the base line beyond the slave the separation of the two pulses will remain at exactly the same value as it was at *B*. This line is the limiting Gee lattice curve, and as we are not using the full length of the time base this first position line need not necessarily be numbered 1. It can be changed by altering the phasing of the slaves in relation to the master, and under present arrangements the delay is 2 whole Gee units (133·33 microseconds) for the *B* slave. At every 6·2 miles interval along the base there will be a change of time difference of one whole Gee unit until at *A* the pulses will have their maximum separation—some 17 Gee units for a base 90 miles long—the actual number of this limiting curve depending, of course, upon the actual separation of the *A* and *B* stations. Thus the *B* co-ordinate of a fix is always discovered between 0 and 25 on the scale. Similarly the introduced delay secures the range for the *C* co-ordinate to lie between the 30 and 55 scale divisions, the upper half of this scale containing the D co-ordinate when a fourth station is used. The charts and maps are labelled accordingly* (Fig. 3). Although the precise value of the time delay introduced at the slave stations is not particularly important, it will be clear that an alteration in the value of the delay will demand a corresponding change in the numbers affixed to the hyperbolic grid.

* The colour scheme used on Gee charts is standardised. Lattice curves for the Master and Slave *B* are shown in red ; the second pair, Master and Slave *C* are shown in green. Thus the navigator on the outward track will have the red curves on the port side and the green curves on the starboard side as is consistent with navigational practice. The third pair, Master and Slave *D* are shown in purple. An exception to this scheme may be introduced on air maps when the amount of woodland makes a rather heavy green plate. Then the Master and Slave *C* pair are printed in blue to avoid the lack of distinction that would result from adhering to the standard over-printing in green.

The system known as Loran (2) is similar to Gee in the essentials of its technique and chart requirements. Some particular features that must be considered when designing the charts result from the system being intended for use at sea and over long ranges. At sea the range of each direct signal, or ground wave, averages 600—700 nautical miles by day. This is reduced by about one-third at night when atmospheric noise renders the signal indistinguishable at more than 500 nautical miles. On land the effective range of the ground waves is 100—150 nautical miles at the surface and about 200 nautical miles in aircraft exceeding 3,000 feet. When signals are transmitted, some of the waves, the ground waves, are parallel to the earth's surface but others travel upwards, encounter the electrified layer of the ionosphere some 60 miles above the earth and are reflected back to the receiver. Although these sky waves are effective only at night they are useful to about twice the day-time range, i.e. about to 1,400 nautical miles. The hyperbolas for Loran charts are computed for ground waves and are labelled in microseconds, but a time difference observed from sky waves can be corrected to the equivalent ground wave reading. To facilitate this process the appropriate sky wave corrections in microseconds are pre-computed for an estimated mean position of the ionosphere and inset at various points on the chart for each pair of stations. Interpolation in any direction between these inset values is easily performed.

In addition to the standard Loran there was developed in 1943 the " sky wave synchronised " or S.S. Loran. The modification consisted chiefly in the use of pairs of stations separated by 1,000—1,200 nautical miles rather than the 200—300 miles in general use at that time. Such a system can be used only at night when sky waves are strong. It was developed primarily for marine navigation and the special S.S. Loran charts were prepared to show hyperbolas based on sky waves only.

It is customary in Loran operation to introduce a coding delay in addition to the normal delay required for indentification of station. With a coding delay introduced as an arbitrary part of the absolute delay use of the system can be restricted



A
B
C
P
44·0
43·0
4·0
42·0
5·0
41·0
6·0
16·0
15·0
34·0
13·0
12·0
38·0
33·0
14·0
35·0
36·0
37·0
11·0
10·0
39·0
9·0
8·0
40·0
7·0

Fig. 1.

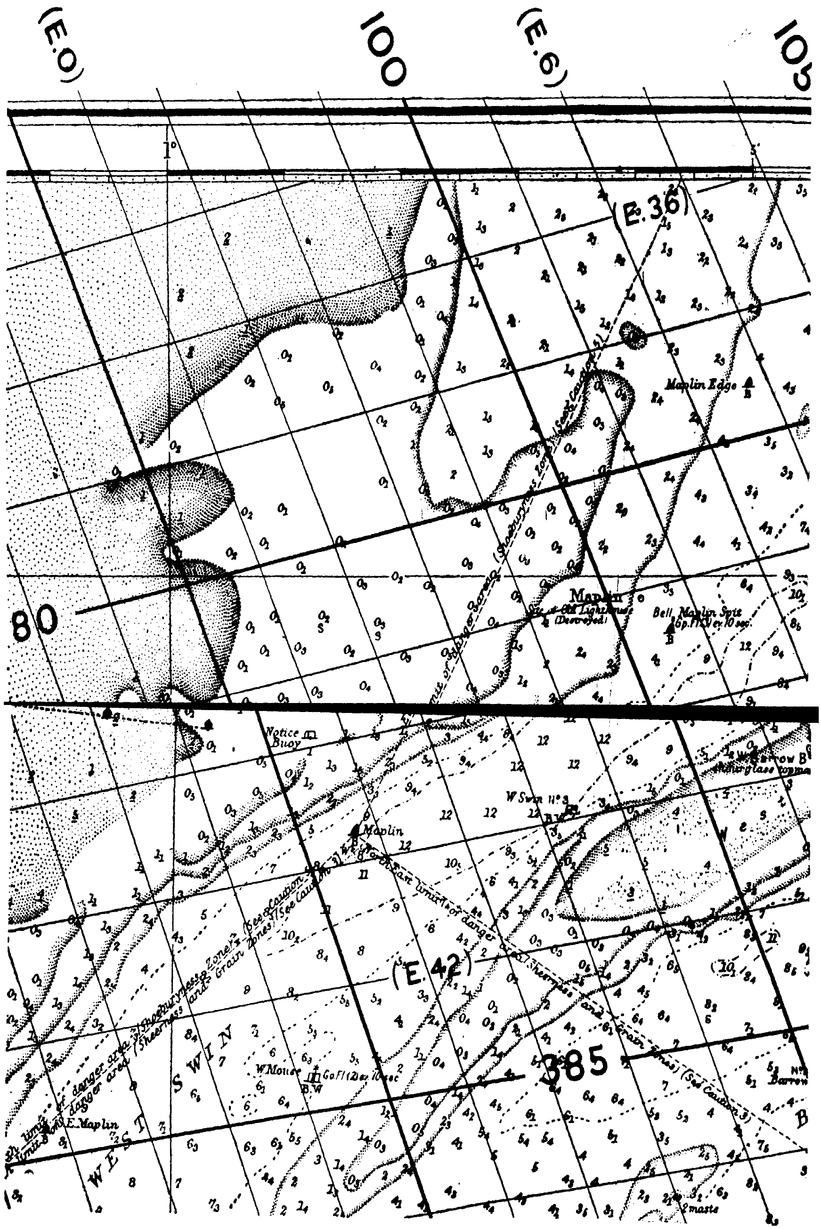


Fig. 2.

Portion of Chart L. 1607 (North Foreland to the Nore). Scale 1/50,000.

Reproduced from British Admiralty Chart with the permission of the Controller of H.M. Stationery Office and of the Hydrographer of the Navy.

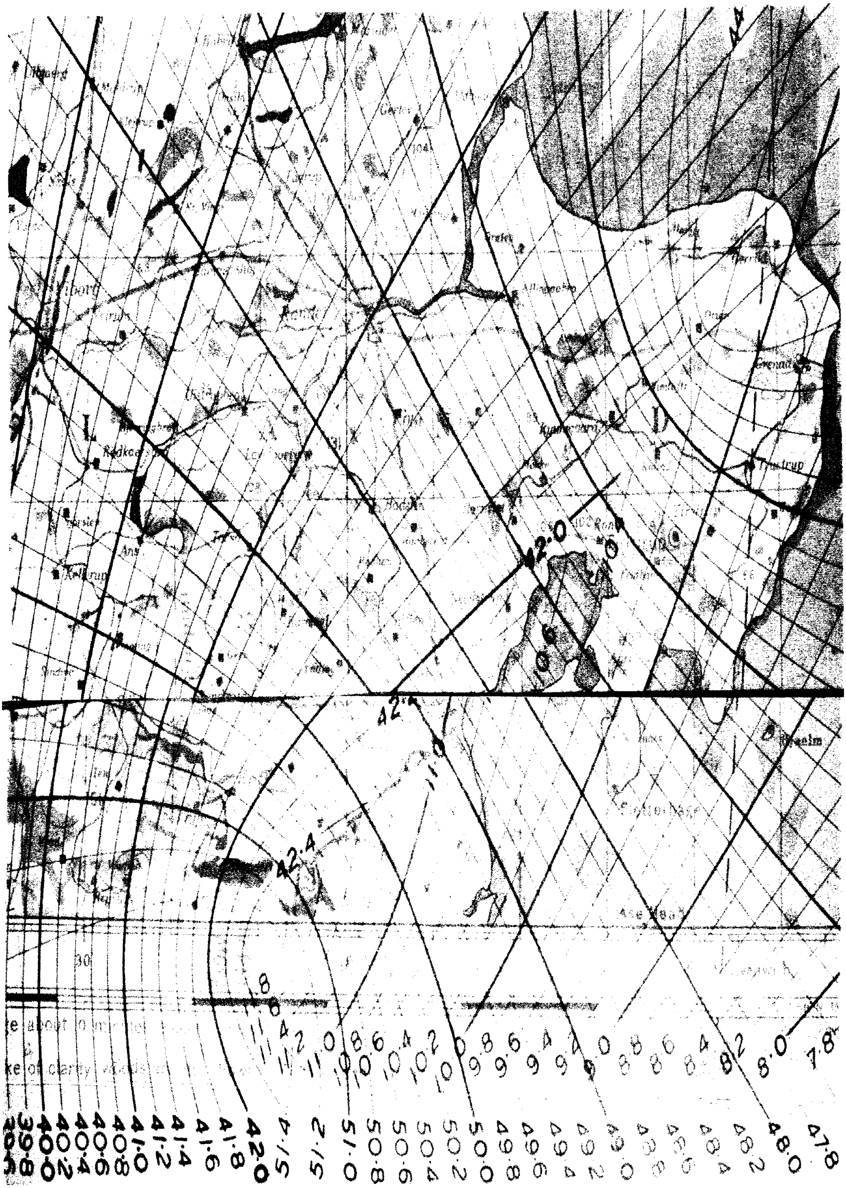


Fig. 3.

Portion of Sheet NE 56/8 (Aalborg) G.S.G.S. 4509. Scale 1/500,000.

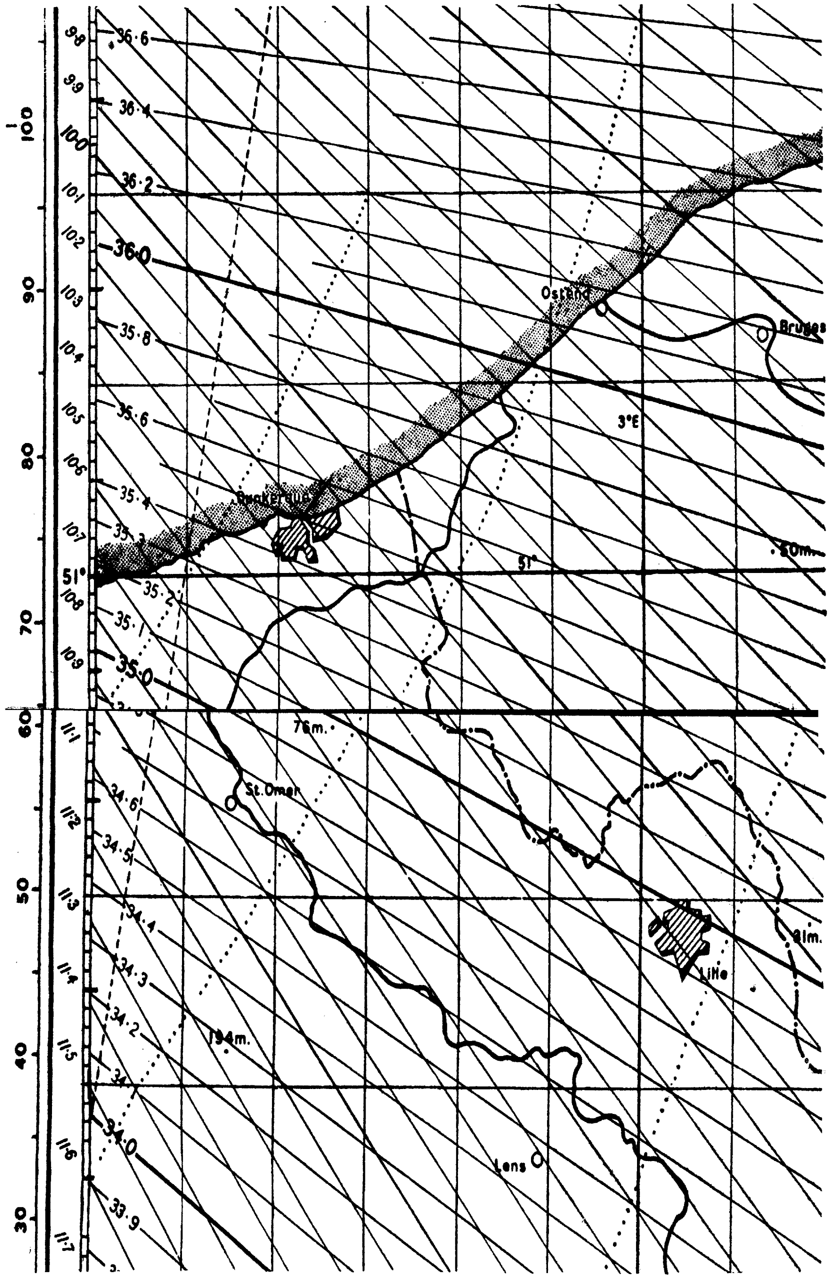


Fig. 4.

Portion of Sheet NE 48½/2 (Dunkirk—Mannheim) G.S.G.S. 4153 A. Scale 1/500,000.

to those who can interpret the measurements correctly by reason of possessing the appropriate charts.

The hyperbolic lines of position are curves developed on the surface of the earth. To plot their courses accurately requires rather elaborate calculation, but since the geographical positions of the transmitting stations are fixed, the lines of position do not change with time as do celestial position lines. Thus the calculation may be performed once for all, depicted on a chart and so presented to the navigator in an easily and readily interpreted form. The hyperbolas will form a co-ordinate system on the chart, by means of which the navigator may plot his position directly from his observations without calculation.

Since the new navigational methods are employed as aids supplementary to, rather than replacing, the time honoured methods of dead reckoning and astronomical fixes, it is obviously desirable to adapt the maps and charts already in use aboard ship and aircraft by overprinting them with sets of hyperbolas in various colours corresponding to the pairs of stations. The earth's spherical surface is not developable into a plane; but while it is not possible to make a map or chart correct in every respect, it is possible to maintain certain definite qualities of the globe in the representation of geographical co-ordinates on a flat sheet of paper. The most important properties to be preserved for navigation are that bearings shall be shown correctly and that distances shall be readily determinable. Although the requirements of air and marine navigators are similar, the projections employed for their navigational charts may differ. Air maps are produced by the Directorate of Military Survey and G.S.G.S., and some of the principal map series in general use by the R.A.F. are simply modified topographical maps—modified so as to emphasise the features that will appear most distinctively when viewed from the air. Thus roads, railways, woods, water areas and settlements required for visual identification of terrain are shown by boldly contrasting colours. In addition will be shown other information necessary for safe navigation such as summit spot heights, aerodromes and landing grounds. The

most important Gee lattice series used for air navigation is based on a military topographical series on a scale 1/500,000. These maps are on the Conical orthomorphic projection. The special properties of this projection that recommended it for artillery purposes, namely that the scale is the same in all directions at any point on the map and varies but slightly within the area of a sheet, and that straight line bearings over short distances are sensibly correct, permit its use as a basis for air navigation by dead reckoning. In addition to the Lattice Topographical maps (Fig. 3), a lattice plotting series on a 1/500,000 scale has been produced (Fig. 4). As range and speed of aircraft have increased there has been a demand for smaller scale maps to embrace larger areas and to meet these requirements a miniature lattice plotting series on a 1/million scale has also been produced. To facilitate plotting both series have been drawn on the Mercator projection.

The charts required for marine navigation are distinguished from maps as being primarily, though not exclusively, a cartographic representation of the underwater features of a portion of the earth. Hydrographic charts necessarily include adjacent coastal areas in order that the navigator may be enabled to fix the position of his ship with reference to the coast and navigational aids and dangers. With the exception of large-scale harbour plans, hydrographic charts are constructed on Mercator's projection. The unique property of this projection if that lines of constant bearing on the globe are represented by straight lines on the chart. This great convenience to mariners who mostly find their way and fix their positions by measuring along a compass course, together with the ease of plotting on latitudes and longitudes drawn on rectangular co-ordinates, and the possibility of accurate measurement of distance despite the scale variations, have established this projection as the unrivalled basis for marine navigational charts.

The differences in the properties of the projections used for hydrographic charts and for some air maps have permitted the use of different techniques for plotting the sets of hyperbolas in their correct relationship with the terrestrial co-ordinates.

From our earlier analogy between radiating waves and overlapping sets of concentric circles, it seems possible that

hyperbolas could be produced graphically on a chart or map by joining with smooth curves successive points of intersection of circles having the same value of time difference. Such construction would result in plane hyperbolas. The geographical positions of points on the lattice lines observed result from development on a spheroidal surface. The geographical positions of the hyperbolas will be truly represented on our maps by the graphical construction only if (1) the extent of the area represented is sufficiently small to reduce the effect of the curvature of the earth to negligible proportions, i.e. that for practical purposes the plane and spherical hyperbolas approximate very closely, (2) the projection on which the construction is carried out also approximates closely to the conditions of the earth's surface so far as preservation of azimuth and distance are concerned.

When Gee was adopted for the R.A.F. it was seen that its range of 200 miles at 5,000 feet to 400 miles at 15,000 feet permitted the first assumption to be made. The maps already used by the R.A.F. were on a projection, the conical orthomorphic, such that the second condition could be fulfilled. For these reasons the Gee lattice curves to be overprinted on the G.S.G.S. maps, of the 1/500,000 topographical series were constructed graphically, any slight displacements of the curves being corrected by adjustment on to the plotted positions of calculated test points.

For the drawing process base plates of enamelled zinc, one for each pair of transmitters, and large enough to accommodate all the sheets to be covered by the chain's service area, are marked for the position of each sheet. The co-ordinates of the transmitters are derived from connection with Primary or Secondary Triangulation stations* in the neighbourhood and plotted carefully, one pair of master and slave on each of the base plates. The construction of concentric circles is facilitated by use of a multiple beam compass. This consists of a metal

* When the stations comprising a chain are all within the area covered by a systematic triangulation the positions of the stations can be found without difficulty; but if the stations lie in different countries, which have been surveyed on separate triangulation networks, the positions of the stations as derived from these different networks must be adjusted into sympathy with each other.

bar in which there is a series of holes, each taking a drawing point. For representation of Gee lattice curves on a scale of 1/500,000 the separation of the points will be equal to the separation of the Gee units along the base line between the master and slave stations, i.e. one Gee unit represents 10,000 metres, so on 1/500,000 scale its value will be 2 cm. With centre on the slave station, and the beam properly adjusted, one swing of the bar will produce a series of concentric circles with uniform increase of radius of 2 cm. By means of a fine adjustment screw the radius of the bar, and therefore of each drawing point, from the slave *B* can be increased, and if successive series of concentric circles are drawn with a uniform increase of radius of 0·4 cm. these will represent increases of 0·2 Gee units. Similar concentric circles are drawn for the master station *A* but so disposed that one of the unit circles passes exactly through slave *B*. By joining together appropriate intersections the lattice curves can be extracted. The base plate contains the hyperbolas for all the topographical maps to be covered by one pair of stations, but the disposition of the curves to be plotted on any one sheet* may be obtained by placing a piece of transparent drawing material over the position of the sheet on the base and the lattice curves are drawn on this. The position of each lattice curve shown on a sheet must join smoothly with that part of the same curve appearing on the adjoining sheet. The curves extend right across the face of the map but are stopped at convenient points just beyond the border and are then annotated with their Gee unit value (Fig. 3).

* Some sheets will contain curves from a particular pair of transmitters over only part of the sheet. Apart from the limits to which resolution of time difference is possible, in the main the accuracy of the hyperbolic systems is determined by the accuracy with which the navigator can determine the points of intersection of the lattice lines. It is a feature common to all the systems that although pairs of stations will give good intersections over the greater part of their area there are certain regions where the hyperbolas tend to become parallel. Here also the spacing of the lattice lines for equal time differences increases and hence the accuracy diminishes. Since intersections in these regions are useless for position finding, the curves are cut out. The positions of the curves deleted are always the same—the area at the base line extension of each station. Similar decrease in the angle of cut, and therefore in its decisiveness, occurs with range from the stations.

Whereas on the conformal projection the slightly warped plane hyperbolas represent the spherical hyperbolic position lines very closely, on the Mercator chart the constant change of scale with latitude produces curves that are noticeably asymmetrical and must be plotted by points. The rapid graphical methods are unsuitable for marine navigational charts for other reasons also. Charts are not schemed as sheets of a series, regularly disposed, and with a uniform scale. Most charts are constructed on the scale of their own mid-latitude, and it is impossible to accommodate varying scales in the graphical method. Moreover, the long range of coverage provided by Loran would mean a territorial extent such that the effect of the earth's curvature could not be overlooked, and would produce considerable differences between the co-ordinates of points as constructed and their computed geographical positions. The data required for plotting the hyperbolic curves on hydrographic charts consist of the computed points of intersection with meridians and parallels of lines of time difference, pre-selected to permit easy interpolation by the navigator. The number of such cutting points required is very large, especially in the vicinity of the stations where their curvature is greatest. Preparation of the basic data has been by choosing points of even latitude and longitude, computing distances from both stations and taking the differences, tabulating the resulting time differences and then interpolating to obtain latitude and longitude for each desired even time difference. This is a laborious process but one adapted to routine machine computation. Through the control of the computed points, plotted on the graduation of the chart to be overprinted*, smooth curves are drawn. The finished appearance of the lines is achieved by drawing with ruling pen along the edge of a spline—a strip of celluloid or similar transparent, flexible but resilient

* When the transmitters are located in one country, yet provide a service cover for territory of an adjoining state, it is necessary to adjust the geodetic positions in the second network, so as to bring them into sympathy with those of the first, in order that the data computed for positions taken from the first triangulation might be directly applicable. An example of this was the adjustment to the graduation of the French hydrographic charts of Normandy in order that the geographical positions of the lattice lines for the British Southern Gee Chain would plot on the correct hydrographic and topographical details.

material which may be bent to form the curve—through the points and which is held in position by weights. Only one draughtsman can be employed at once on the curves formed by one Master-Slave pair of stations. A lattice chart containing three sets of hyperbolic curves would occupy a cartographer and two draughtsmen two or three weeks, depending on the size and scale of the chart. The final stage in production is the transfer of the lines of the drawings to the zinc printing plates by the lithographic draughtsman. One plate is required for each of the distinctively coloured sets of hyperbolas, and since the original plotting has been done from the graduation of a dry proof of the navigational chart to be overprinted, the curves should fit with an exact register.

To conclude my lecture I shall refer briefly to some of the ways in which use of hyperbolic navigational charts can assist the air or marine navigator. Perhaps the greatest benefit conferred is the ability of fix position at long or short ranges (*a*) in conditions of poor visibility which prevent celestial observations and terrestrial fixes, and (*b*) in all weathers (except heavy lightning in the immediate vicinity), for unlike dead reckoning, observations are almost as easy to make in rough sea or air as in smooth. Thus the navigator can check that the ship is proceeding along the intended track and so remove the risks of grounding, notwithstanding any unpredictable sets due to tidal streams, currents or winds. Many navigational problems can be much simplified when it is possible to work from a hyperbolic chart, e.g. rendezvous between ships, or between air and surface craft, in areas of poor visibility, or the organisation of patrols for surveying swept channels or for mine sweeping. This latter problem can be schemed advantageously on the lattice chart and a programme for operations be compiled in terms of steering along a chosen position line to a terminus indicated by an intersecting position line of a particular value, then reversing course and following an adjacent line. In this way the area may be covered in " lawn mower " fashion with certainty and simplified navigation. The application of similar parallel tracks, of known separation, to routing of aircraft in dense traffic areas has such obvious merits as a safeguard against collision as to need no elaboration.

The development by the various hyperbolic systems of a means of accurately determining the position of a point with reference to known points has opened up very considerable possibilities in the field of survey (3). For this it would be necessary to establish three stations, a master and two slaves at accurately determined points, and around these a plotting chart can be built up on the computed space pattern of hyperbolas. A survey unit, R.E. survey vehicle or hydrographic surveying ship with appropriate receiver, may have its fix defined with regard to the hyperbolic pattern and hence to the position of the three radio stations. A particular advantage of this method is that connections over wide stretches of water can now be accurately made. This should be of particular value to the hydrographic surveyor who has hitherto been in some difficulty regarding construction of charts in areas such as the various Pacific ocean groups where islands are too widely separated to be reached by optical means. The hyperbolic fix would be of great service also for the accurate location of shoals, reefs and other hydrographic features beyond the range of visual position fixing from shore stations.

It is perhaps as a control for air survey that hyperbolic systems have most significance for modern mapping. Radar controlled navigation, when flying strips for stereoscopic pairs, enables the air photo cover to be obtained efficiently, in that it is gap free, and economically in that allowance of lateral overlap necessary to ensure adequate ties between adjacent strips can be reduced. The track value of successive strips can be determined from the chart according to the charted width of the photo strips, allowance being made for overlaps. Even if one or two strips of a sortie are failures because of clouds, other defects or camera failure, it is a simple matter to fly those strips subsequently exactly in position. If the taking of photographs of the radar fix, displayed on the cathode ray tube in the aircraft, is synchronised with the taking of the survey photographs, the position of the aircraft at the moment of exposure may be determined in relation to the surface of the earth. The inclusion on the automatic observer's photograph of other instrumental readings, such as the altimeter and indications of fore and aft and lateral tilt, permit control,

previously fixed by ground surveys, to be very largely superseded by control points computed in ground position from the radar fixes, and if necessary, without access to the area. In the opinion of Lt.-Col. C. A. Hart (4), who initiated the first experiments in the employment of radar as an aid to air survey, "by a suitable arrangement of stations accuracy of location to half a mile or so can be achieved on sea or in the air by day for ranges up to 600—700 miles" (with low frequency pulse system such as Loran, or low frequency radio phase difference system such as Decca). Thus it should be possible to map from air photos at these ranges at reconnaissance scales of 1/250,000 or ¼ inch to a mile. For initial topographical surveys of comparatively unexplored areas such as Northern Canada, or unmapped countries such as China, the application of radar technique to survey methods may become equally important as the application of air photography.

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Natural Philosophy and the Fine Arts

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In the middle of last century John Stuart Mill contributed an essay, over the pen-name "Antiquus", to the *Monthly Repository*; the title was "On Genius", and he displayed in it all the passionate veneration for ancient Greece which was indeed the background of his life and work. But he did more than that; he brought to light the place which "conceptive genius" should occupy in men's minds and thoughts. It is tempting to say conceptive genius in contrast to creative genius, but this would be a mistake, for the philosopher had no desire to place the two in opposition; indeed he merely wished to compare them, and to secure for the former that degree of recognition and appreciation which it seemed to him to lack. Translated into more modern guise, we are faced with the activities of discovery and of criticism. And who shall presume to give the prize to the one and a *proxime accessit* to the other? I shall leave these talents side-by-side on their pedestal now, merely remarking that we shall need both of them if we are to ponder fruitfully this evening the interplay of pure science and fine art, in an attempt to see what genius has accomplished throughout the ages—and alas!—the price which has been exacted in the process.

The love of beautiful things and of learning for its own sake without thought of reward, characteristic of the golden age at Athens, and later, amongst other centres, of Syracuse, was not wholly restricted to philosophy and the sciences; sculpture, architecture, ceramics, paintings, all found their part, not of course at all times and in all places, but generally; broadly too they all carried intellectual weight, as witness the arithmetical proportions of the Parthenon and the deliberate nature of the geometrical designs upon much Greek pottery.

Further instances will readily occur to everybody; the construction of mosaics in obedience to the theorem of Pythagoras (only achieved by making the putty fill up the imperfections), the presence of advanced forms of symmetry in the pattern of ornamental shields, and so on. It seems clear

that thinkers and " makers " were as one in those days; they thought and they " made " for sheer delight, and for no other reason. Not only were they blessed in this state of mind; there was the consequential result that the arts and sciences knew not that separation which they were later to experience. Perhaps they are a little closer again now, except for the seemingly perverse views of some who appear to rejoice in stressing their incompatibility.

The story is told of Chwistek, the Polish scholar, that he, when a child, informed his mother that he wished to become a painter, but she, with sound common-sense, reminded him that he must do something more likely to provide a living. So he entered the University to read mathematics, in due course becoming Professor of Logic. All of which is essentially historical truth, though the emphasis may tend to be slightly apocryphal. The point is, however, that creative genius and conceptive genius seem more like natural twins than accidental ones, in this case at any rate.

We thus arrive, by implication, at a position where one is forced to look very carefully at the orthodox conception of the beautiful. Chwistek, doubtless immature, grasped at it in pictorial art; later he was to learn a still harder discipline, to conceive and to construct the beautiful in mathematical logic.

And what a beauty it is, powerful and majestic as a work of Michaelangelo, and showing the same signs of intense creative strife.

Let us be cautious in asserting our satisfaction at having extracted all the beauty there is in a picture or a statue by that great master; we must as much—in humble duty bound—try to discern it and to realise it in symbolic logic. The impact of natural philosophy (that grand synonym for physics north of the border), upon the fine arts has just this quality, the necessity, the absolute necessity, of keeping the emotions in check, whilst allowing them complete liberty to make great art that which only they can make it. Perhaps the most sublime picture in existence (so those competent to judge sometimes say), is Piero della Francesca's " Flagellation ".

Pure emotion ; yes but coupled with infinite restraint. Somehow or other, these apparent opposites have to learn to live together ; we disturb the balance at our peril.

And so we discover, if we take enough trouble, great artists undertaking abstract tasks of the mind ; the architect of Santa Sophia writing on the regular polyhedra, Dürer on the partition of planes, and perhaps above all, Leonardo da Vinci bending all his massive powers to study the works of Archimedes—and not without success. But the stream is by no means entirely in one direction, for in our own day Birkhoff turned—for a time—from pure mathematics to probe formal beauty and produced his "Æsthetic Measure", while Andreas Speiser in his "Mathematische Denkweise" has shed new light—and new charm—upon the nature of ornament and pattern. These things are not exactly easy reading, yet to study them is to find oneself in a world where reason and emotion can co-exist.

To leave matters there, however, would be to run the risk of appearing lop-sided, if not indeed irrational. So I must hasten to bring together before you Goethe who opined that, whereas his poetry would perish, his science would remain. Events have proved too much for him, yet he managed to produce something like an impact of art upon science, rather than the other way round. He set out, you recollect, to study light. Unluckily, however, he selected perhaps the most unsuitable of all optical phenomena for the purpose, namely, the passage of light through turbid media. I need not weary you with the details and the rather absurd controversy with Newtonian Physics which followed. But Goethe loved nature devoutly ; it was what he saw that intoxicated him ; how it all worked concerned him not the least. The visible spectrum alone had significance ; all the rest of the electromagnetic frequencies were literally nowhere. He could not sense them, and therefore they held no interest for him—maybe even no existence. And so on. To men of science, such an outlook seems a travesty, yet no less a scientist than Sir Charles Sherrington has given us in his Deneke lecture (Oxford, 1942), a word-portrait of Goethe, executed with an understanding, nay more, a gracious tenderness, which makes one realise the stature of the poet-philosopher, faults and all.

Occasionally most of us have probably approached Goethe's point of view more closely than we care to admit. The transcendent beauty of sunset over a northern loch or the majesty of a storm at sea provoke dispositions of their own, mainly visual and emotional.

We are not denying our scientific heritage, but for the moment it is subordinate; for the moment—but for Goethe the moment was a life-time. Yet he was not without honour in circles distinguished for their addiction to natural philosophy. Goethe was elected an Honorary Fellow of the Royal Society of Edinburgh during the Presidency of Sir Walter Scott, surely an appropriate gesture, both timely and revealing.

These subjective instances apart, there is a feeling that we stand to-day in need of greater unity of thought over wide areas of human endeavour. The characteristic of the scientific method is to isolate a particular band of truth (how wide or how narrow nobody knows of course); namely a strip containing that which can be measured. By so doing, the triumphs of science have been achieved. But it seems that there are other truths, incapable as yet of metrical conquest, perhaps for ever so, and moreover lying at very great depth in the scheme of things. Art is hovering around those regions, and other subjects as well, too vast to tackle now. But to the theological virtues of faith, hope and charity may we presume to add a fourth—integration?

Here we may find the bridge which joins our discussion with that which it to follow. (Meanwhile, I am sensible of the honour which is mine just now in addressing a Society devoted to the cultivation of literary and philosophical pursuits, and it is on the latter account that this concept of integration is presented to you at this juncture.)

We have just seen that the basis of scientific progress is measurement. Lord Kelvin, many years ago, stated that when we have measured something we begin to know a little about it. Within the "narrow band" already mentioned, this is a truism, but outside it (and I assume that you will agree with me that there *is* an "outside") matters are quite different. In fact, if knowledge characteristic of such a "Universe of Discourse"

was only to be obtained metrically, it is probably not too much to say at once that we should be condemned to perpetual ignorance. Here, naturally, one needs to walk like Agag; it is not being suggested that *because* we find numerical data beyond us, *therefore* we are going to be content with qualitative generalisations, persuading ourselves en route as it were that measurement does not matter. We are going to be more robust than that, and to experiment with the notion that the quantitative and the qualitative are but two facets of a single truth. Otherwise expressed, we shall try to integrate phenomena in such a fashion that the whole is more (sometimes much more) than the sum of its parts.

As some psychologists have phrased it, life is not merely a set of " and- summations " (a very expressive term, " and-summations " being entities of the type a-and-b-and-c-and-d- . . .); it is rather a whole, composed of lesser wholes. This indeed is the theory of *Gestalt.*

Nobody has yet succeeded in arriving at a satisfactory English equivalent of that word. Actually, the more one tries, the more clumsy the result, so I suggest that, with most scholars all over the world, we simply speak of *Gestalt,* and leave it at that.

(The translations usually accepted, with reluctance, are " shape ", " form ", " configuration " : all rather pedestrian.)

But it will have struck you no doubt how illuminating this integration into wholes may be for a view of creative art. To that I will return in a moment as my main theme; it is tempting however to digress for an instant to show you what happens—in a totally different context—once we are (or somebody is) audacious enough to break away from limitations hitherto man-imposed and man-accepted.

I refer to the development of algebra. To Diophantus of Alexandria—in the third century A.D.—we are indebted for the symbolism of the common discipline taught to most of us at school. Such an algebra is generalised arithmetic. We take x as any number, and so forth. But in the hands of Boole and others it could be much more than a mere number, it could denote a class or a relation and thus become co-extensive with

much of logic. All this was a hundred years or so ago—and we have only to contemplate the amazing development of metalogic, metamathematics, metalanguage and (generally) metatheory in quite recent years to see the possibilities which await investigation once number *qua* number is merged as it were in a new and even more powerful instrument of thought.

In psychology, *Gestalt-theory* is much more primitive, but its aims are scarcely less revolutionary.

Perhaps the best approach to the essence of *Gestalt* ever achieved is Wertheimer's suggested several decades ago. He imagined a great company of minstrels assembled together and about to play their instruments. They could, he said, go ahead in any one of three ways—

(i) Each might sound any note he liked and when he liked, and the result would be chaos; or

(ii) When one played *a*, the next played *b*, and so on, according to some agreed rule. This would not end in confusion, but merely in (musical) nonsense; or

(iii) Everybody in the orchestra should have his predetermined and purposeful part to play in a concerted whole—an "organisation" as we say. The outcome is a symphony.

Now the interesting point to notice is that this wholeness, or *Gestalt-quality*, involves the audience as well as the performers. It is most improbable that anybody would enjoy, or indeed understand, a great classical composition (or even any other), by singling out each note or part and, so to say, tying a label on it and clasping it firmly but out of its context.

For some good (analytical) reason this might be done, but it is assuredly not the end or goal which it was intended to reach. In much the same way, minute attention to the details of a great painting is for some kinds of art history of great value, but it could not be seriously advanced that such an attitude corresponded in the least with the main object of the artist, to give pleasure, to impart a message (or whatever it may be) as a whole.

This brings us, I believe, easily and naturally to the very core of our problem, namely the places to be assigned in art to creative and to conceptive genius.

With your permission, we shall pick our way very carefully hereabouts, using as the surest guide we can find the mathematical background already sketched in.

Furthermore, I shall illustrate the process by reference to paintings, partly because I feel slightly less incompetent with them than with other things, and partly because we have some objective evidence concerning them which may help us to see how the significant " organisation " corresponding to a *Gestalt* tends to come about. For this we have to thank physics, or at least the application of physics, to pictures.

Before submitting a typical example of *Gestalt* integration for your attention, and with the mention of physics fresh in our minds, please cast your memory back to days when you experimented with a Wheatstone bridge, or potentiometer, and were bidden to observe the way the electric currents were distributed or shared amongst the branches of the network when a balance was obtained on the galvanometer.

The condition of zero deflection is that the work done should be a minimum. And again, if other resistances are substituted for those previously in circuit, the currents readjust themselves to regain minimal work. And similarly for other phenomena. Now this is what is sometimes called an " Extremum "—the system tends to a limit which may be maximal or minimal : at any rate the end result is an " Extreme Value ", that is, of course, if time is allowed for equilibrium to be established rather than that the state of affairs should remain metastable or labile.

In the latter event some latent energy will be present, tending to drive matters to a new, and perhaps final, state of rest. All occurrences of this kind possess an implied, if not immediately apparent, teleological tendency, that is we become interested in ends rather than in means, or in end-states rather than in paths. To this I will return.

You will doubtless have noticed the parallelism between much of this, and the construction of a great work of art, say a painting. How can these conceptions be made more precise ? In what is technically known as the connotative region of art exactitude as yet escapes us (as well it may, from what has already been said on the subject of metrology), but we can, I

believe, get a little further before we have to stop. The need is to set up a relation, however tentative, between two quantities such that some qualitative connection exists between them. The most obvious pair to try are free-energy and "organisation" (O). Mathematically, we may write $E_f = f\ (O)$. By the former we envisage the energy content of a painting (considered as an abstraction) which it has at any moment of its construction, causing it to change, not of course mechanically, but by the will or conatus of the artist. When perfection, or what passes for perfection, is attained, this E_f will be a minimum or extremum (as we have already said), otherwise change would set in and the state would not be that of rest. With regard to "organisation", this clearly has a geometrical counterpart, being concerned with such visual questions as balance of masses, grouping of figures, partition of the whole area into characteristic areas, for example, the triangular habit of Veronese or the verticality of Tura, and so forth. It now seems clear that our function $E_f = f\ (O)$ is akin to potential: we are plotting energy against a length or a power of length (e.g. area). Can we say anything at all about the form of the curve? Theoretically, nothing whatever; empirically, "yes". And for this reason we can in favourable cases investigate how the artist built up his design, more especially if he made more than one attempt, as he often did. By means of X-rays—using very soft radiation at about 10 KV—one can follow successive modifications—as revealed underneath the finished work—to obtain better and better posture, poise, relation of light and shade, or whatever it may be. In other words, we can, qualitatively, plot out the course of this O co-ordinate (the independent variable so to speak), and discern how this search for a minimal free-energy was progressing. Sometimes an obvious touch in the right direction is followed by some change less satisfactory (leading away again from the minimum), until finally an artist appears to get the result he wants; a great work of art is finished and repose is obtained. With great care we can venture a step further—in our quest for the shape of our energy-organisation graph. Thus, history of the lives and efforts of great artists (and others) demonstrates clearly the immense amount of labour involved in covering the last lap,

i.e. on the " creative " side of an energy minimum, the free-energy decreases very slowly: extreme " pressure " is demanded in much the same way as Professor E. A. Milne speaks of sufficient " logical pressure " to bring about future discovery. Once, however, a minimum is past (the artist over-shoots the mark by working too audaciously or carelessly) the free-energy rises rapidly, i.e. the sensation of repose is patently destroyed. Everybody knows—and most people can see quite readily without excessive training or knowledge—when the artist has gone just too far (not knowing when to stop), and ruin results. So, in the neighbourhood of an energy minimum our curve is like this (organisation increasing towards the right),

 not like this→ 

In common things we have all at one time or another seen somebody do something " just so ", and have exclaimed, "For heaven's sake, stop ". That is what all this amounts to.

But more can be extracted from the subject yet.

We have taken repose, or sensation of rest, as the criterion of universal free-energy and implication of the " best organisation ". What is this " best " ? In *Gestalt-theory* there is a statement called in law of Prägnanz, and it says, " Psychological organisation will always be as good as the prevailing conditions allow ". " Good " means " regular ", " symmetrical ", " simple ", " satisfactory " and so on. It will be clear to you now how close we have been all this time to the " symmetrical " arrangements so commonly and beautifully exhibited by nature in a state of equilibrium or repose, e.g. crystals, soap bubbles, etc. We have tried hard to follow the artist along the curve of *Gestalt* organisation, using X-radiation as our tool. There is another way as well, not very likely to tell us of " love's labour lost " so cruelly, or of triumph gained so casually, and that is the application of the infra-red to paintings. The technique is quite different, and I will not burden you with details, but the point is this, and a very limited point it is. Certain painters, for example Cossa, Crivelli and Tura, were in the habit of performing an extreme amount of undermodelling

in rendering their figures. This feature is nearly invisible—sometimes entirely so—in the finished work, but is so happens that infra-red rays will penetrate the extremely thin surface paint and reveal this rugged "anatomy" below. The effect is as if these artists went to their task as body-builders, in very fact, producing direct evidence of morphoplasticity. But all this is—to a first approximation—smoothed out afterwards, and one is left with an uncanny sense of realism in the limbs, due, we know now, to the masterly way in which they were conceived and executed. At the *Gestalt* angle, however, we are convinced that these men knew exactly when to call a halt with their anatomy. There is nothing excessive or disquieting on the surface, but exact knowledge and technique have done their work underneath. Even without scientific equipment it is occasionally possible to discern in a Rembrandt etching or drawing the same sure instinct for a free-energy minimum, unconscious though it may have been.

In terms of our theory, a picture is a *Gestalt*; modification, subtraction or addition implies a disturbance of balance, and new relations between the parts are called for if equilibrium is to be restored. It is clear how close the analogy is with Wheatstone net. Incidentally, in matters of the arts, we are unlikely to get far beyond reasoning by analogy—an unfashionable form of thought-process, and the lowest in the traditional hierarchy, because of its obvious weakness in passing only from particular to particular instead of from particular to general (as in induction), or from general to particular (as in deduction). Nevertheless, a number of interesting possibilities are revealed. Works of art are fundamentally special cases—each one of them—and our methodology needs to be correspondingly individualised if we are to make any progress. A more general concept is naturally of very great value and importance but leads automatically to a broad system of æsthetics, which is not what we are discussing this evening. What I am pleading for just now is a wider acceptance of a disciplined methodology in appraising beautiful things than we have been accustomed to apply hitherto. There are, of course, grave limitations to the ponderous German approach

to problems of stylistics, criticism and so on, but one thing does come out of it, and that is a due training of the conceptive faculty, leading in the most distinguished scholars, to something like the genius of which John Stuart Mill wrote. This integration of which I have been speaking is a quality of mind itself, a kind of intellectual virtue as it were.

So far I have confined myself mainly to objects of art as such, with perhaps incidental reference only to those mainly responsible for their creation. This way of looking at our subject has been deliberate, because I wanted to try to put before you the imbrication, so to speak, of science and art as seen in a philosophical and historical setting.

There is, however, another side to the matter, and to this I now address myself.

In recent years there has arisen a new interest in scholasticism and the *philosophia perennis*, which term by the way we owe to Leibnitz. The reasons for this particular renaissance are complex and various and need not concern us now. But the main feature of this system of knowledge is its comprehensiveness, or solidarity ; it is capable of absorbing into itself a very great variety of human experience and enterprise, and on this account we welcome it in any effort to make common ground between scientist and artist. At the same time something else is going on, and that is a kind of revolt against the materialist, mechanistic view of biology. The leader of this functional outlook is Dr. E. S. Russell, whose recent book " The Directiveness of Organic Activities " seems to me a most stimulating and important event. Its reference to our scheme will soon become clear. His position is that the search for physico-chemical processes in living things is bound to prove unsatisfactory (though he does not deny the importance of such work), and that progress can only come by considering " directiveness " (conatus, drive or urge) as paramount. Philosophically, this is straightforward Aristotelianism, potency being transformed into entelechy. I am now concerned exclusively with the artist—not with the thing he produces.

Murray, in 1938, proposed an expression of the following kind to symbolise the " directive " method, namely,

$$(BS) \rightarrow (SS) \rightarrow (A) \rightarrow (ES).$$

Here (BS) stands for the "beginning state", (SS) for the "stimulous situation", (A) for the "action", and (ES) for the "end-state". Murray's view was purely biological in essence; I am myself taking the liberty—approved as a matter of fact by Russell—of extending his formula to purposeful phenomena rather than to automatic ones. Thus, at some moment, an artist is in potency; he is in the condition (BS), that is he is theoretically capable of producing a work of art. Then, some circumstance or set of circumstances stir him to start, i.e. the situation (SS) exists: action (A) occurs, and after more or less strife the picture, or whatever it is, is produced, and his goal or end-state (ES) is ultimately reached.

Now this in itself is not very remarkable; what is intriguing about it is the neat way in which it sums up and contains within itself the core of the theory I have already tried to explain from the *Gestalt* aspect. You will observe that the artist is assumed to reach a stationary state with (ES): his mind then is at rest and his work done. This is what corresponds to the minimum of free-energy E_f in our potential function for the picture. I would repeat once more, $(BS) \rightarrow (SS) \rightarrow (A) \rightarrow (ES)$ is only a conventional short-hand. It is the implications that matter. There are several, but I shall only refer to two of them. The very form of the expression will probably suggest to physical chemists Le Chatelier's principle and the law of mass-action.

The former, you will remember, asserts that once a system is displaced it meets forces which tend—on the whole—to slow down, and perhaps in the end to stop, further movement. The law of mass-action may be stated in various ways, but the simplest for our present purpose is that, in a chemical reaction the "yield" depends upon the products formed, and that, in practice, this "yield" is rarely 100 %, due to the reverse action set up by the substance liberated by the initial decomposition, or whatever it may be.

Now something akin to these two effects is very common in the history of art. A great work is started: the desire to achieve declines, sometimes a picture is left unfinished for years, and then (SS) appears again, apparently fortuitously, and progress ensues.

Occasionally sociological forces come in, and sometimes a whole "school" has become moribund in the face of some reactionary influence. Then again it is remarkable how great art may become sterile, and seemingly abortive, if it lacks interpretation, i.e. conceptive genius as well as creative. This task of carrying a message or meaning has often been performed by some person wholly other than those engaged in creative production. Well-known instances are the "missionary" work of Thoré on behalf of the Barbizon School in France, and our own John Ruskin for Turner and the Pre-Raphaelites. The law of mass-action is reflected in art not so much as regards the impact of resistances; its subtle influence amounts to a kind of autotoxic effect in which the very virtues of the master—and perhaps of his pupils if he has any—clog the machine as it were and reduce the efficacy (not the efficiency) of their own work. What is then needed is some outside influence—to save them from themselves—and thus to remove the stultifying reactants from the scene. In some cases, however, there seems to be a catalyst already at work, and the transformation continues to go merrily ahead with unabated vigour.

Lest all this should seem too abstract and intangible, let me add that nothing is ever likely to take the place of experience, either in creative art or in conceptive criticism. But this experience, or empirical element, should be a sort of green belt or "lung" of the mind, and not merely an open space to scamper about in. It is an essential ingredient of art, and influences the beholder as well, as he grows in conceptive stature.

The burden of what I have been trying to say is the unity in essentials between the arts and sciences. But such a condition implies a pre-condition, and that is the existence of a common language. By this I do not mean a mere collection of agreed words or terms (important as that may be), but the establishment and due appreciation of a philosophy acceptable to both. So far, modern writers have tended to point out our differences, which may be salutary, but many of them are more hypothetical than actual. Maybe, it seems to me, that the *philosophia perennis*, moulded as twentieth-century needs require, will go a long way in the right direction. Above all, let nobody imagine

that this system of knowledge looks askance at experiment and speculation; on the contrary St. Thomas Aquinas urged his followers to try and to test, while the year 1879 produced a call to action of the same sort. And to-day, neo-scholasticism is very active, sometimes in most unlikely places. This is far from saying that anybody need think that way if he or she does not want to (and even then only after having investigated the alternatives), but it is worth remembering that generations of scholars of all kinds, and in many lands, have made progress along that road, the creative and the conceptive hand in hand, joined in a common purpose to seek truth and beauty wherever they may be found.

In the Middle Ages, moreover, there was a custom according to which this time of the year*—indeed this very week—was dedicated to the praise of wisdom. We might perhaps do worse than close this discourse by recollecting the antiphonal supplication commonly used in those days—"*O Sapientia,* which camest forth out of the mouth of the Most High, running from one end of the world to the other mightily, and sweetly ordering all things—Come and teach us the way of Prudence".

* Mid-December

The Tides.

By J. Proudman, F.R.S.

I shall divide this lecture into two main divisions, the first being concerned with observation and measurement, and the second with the results of theoretical work. In the first of these divisions I shall deal successively with coastal tides, estuary tides and tides in seas and oceans. In the second division I shall first say a few words about the cause of tides and then deal at some length with attempts to ascertain the distribution of tides over seas and oceans.

Coastal Tides.

As observed from a place at the sea-side, the chief phenomenon of the tides consists in the rise and fall of the surface of the sea, with the two important recurring states of high water and low water.

The measurement of this rise and fall is generally made by an automatic *tide-gauge*. Essential features of such a gauge are: a well having free communication with the sea, the connecting pipe being below the level of lowest low water; a float on the surface of the water in the well; a cord or metal tape to connect the float to a wheel; a reduction-gearing to reduce the range of movement; a pen to draw a line on a sheet of paper covering a revolving drum; and a clock to drive the drum and act as time-keeper. There is, however, another type of gauge, in which the recording part may be some miles from the well, the connection being electrical. In this type of gauge there is a well, a float, a cord and a wheel as in the ordinary tide-gauge; but there are also electrical devices for transmitting the movement of the wheel. There is such a gauge at Birkenhead, the well being at the entrance to the Alfred Dock and the recording part in the Liverpool Observatory at Bidston. Fig. 1 shows a fortnight's record taken from this particular gauge; the first day's record has been thickened. The outstanding features of this record are the phenomena of *spring tides* and *neap tides*. The vertical difference in levels between high water and low water on the

same day is known as the *range* of tide on that day; and this record shows that the range of tide is about 30 ft. at spring tides and about 15 ft. at neap tides. The level midway between high water and the next succeeding low water is always about the same; this is known as *mean tide level.*

The table shows the spring range, neap range and mean range at three places.

	M.S.R.	M.N.R.	M.R.
	ft.	ft.	ft.
Liverpool	27	15	21
Avonmouth	44	23	33
Head of Bay of Fundy	50	37	44

The tides at Avonmouth are the largest on the coasts of the British Isles, and the tides in the Bay of Fundy are the largest in the world. On the coasts of the Pacific Ocean there are places where the range of tide exceeds 12 ft. but at most places in that ocean, and especially on the shores of the islands, the range is always less than 2 ft. On the coasts of the Mediterranean the range of tide is even less than 1 ft., except in the Adriatic Sea.

Fig. 1 illustrates the familiar fact that high water occurs later each day, as does also low water. On the average high water occurs 50 minutes later each day, and as there are two tides per day, this means that the length of time between one high water and the next, is, on the average, 12 hours and 25 minutes. But the daily retardation varies over the month; it is less at springs than at neaps, a phenomenon known as *priming* and *lagging*. The period of 12 hours and 25 minutes immediately suggests a connection with the motion of the moon, because 12 hours and 25 minutes is exactly half the mean lunar day. It follows that high water at any place will occur at about the same interval of time after the moon crosses the meridian of that place, if both upper transits and lower transits are counted. Such intervals of time are known as *luni-tidal intervals*. Though they are subject to considerable variation, their mean values constitute important tidal constants. For Liverpool the mean high water interval is 10 hours, 56 minutes; but if the average be evaluated for the days of new moon and full moon only, the result is 11 hours, 17 minutes.

Not only is there a connection between tides and the moon but there is also a connection between tides and the sun. Spring tides occur one or two days after new moon and full moon, so that there is a fortnight between one set of spring tides and the next. Also, for a given place, spring tides occur about the same time of day ; for Liverpool it is about 12 o'clock.

There are, however, a number of places and regions at which the tides have exceptional features. For example, at Southampton there is a *double high water* (Fig. 2) ; at Portland there is a *double low water* ; on the coast of Western Australia the average period is 12 hours and not 12 hours and 25 minutes ; while in the China Sea at certain times of the month there is only one tide per day and not two.

Estuary Tides.

As a tidal wave progresses up an estuary, it rises more quickly than it falls. This is shown by Fig. 3 which gives tidal records from two places on the St. Lawrence ; at Father Point, which is on the lower part of the estuary, the time taken by the rising tide is about the same as that taken by the falling tide ; but at Quebec, higher up the river, the time of rising is much less than that of falling. The phenomenon may develop to such an extent that the early part of the rising tide progresses like a wall of water and then we have a *tidal bore* or *eagre.* Perhaps the best known of all the bores is that in the River Severn, in which, at springs, a wall of water 7 ft. high may rush along at 20 miles per hour. But there is also one in the Solway Firth and this is made the subject of one of the scenes in Scott's " Redgauntlet ". There is a tidal bore in the Petitcodiac River, off the Bay of Fundy ; here, at springs, the wall of water is about 5 ft. high, but this sudden rise is only a small fraction of the total rise from low water to high water. The phenomenon may be compared with that of a wave breaking on the sea-shore.

Tides in Seas and Oceans.

If we are in a ship at a distance from the land, then we are not aware of the rising and falling of the tide. In order to measure the rise and fall it is necessary to find some means of measuring the variations of depth of water above a particular

point of the bottom. For the great oceans this has never yet been done. But for shallow seas, such as those around Great Britain, it has been done by means of automatic recording *pressure-gauges*. If we can get a record of the variations of pressure on the bottom of the sea, then we can calculate the variations in the height of water above the bottom. An instrument designed by M. Favé is left at the bottom of the sea for a week or more and then, when it is recovered, the record is read by means of a microscope. This gauge has been used at a few places in British Waters.

In estuaries, seas and oceans, the rise and fall of the surface of the water is only part of the phenomena of the tides. There is also an oscillating horizontal movement known as *tidal currents*. It is easy to see that such currents must exist. In order to pass from low water to high water in the Mersey, a great volume of water must pass into the estuary from the Irish Sea, and this means that a tidal current must be directed into the estuary. Similarly, when the water in the Mersey is falling, currents must be directed out of the estuary. Many instruments have been invented to measure tidal currents, but I will mention three only. The first is Carruthers' vertical log. At the bottom of this instrument there is a fan, and higher up there are cups, as in Robinson's Anemometer. These cups are attached to a rod and as a current passes the instrument the rod is made to rotate exactly as in an anemometer. The rotation of the rod is transmitted through a rope to a counting mechanism attached to a boom, and this counting mechanism is made to indicate the distance the water has moved past the instrument in a specified time. It works in exactly the same way as a patent-log measures the speed of a ship. The next is Ekman's current-meter, which has been more used in the open ocean than any other current-meter. Like Carruthers' meter it measures, by a revolution-counting device, the distance the water passes in a specified time. But it also measures the direction of the current by the dropping of balls from the end of a magnetic compass into a box with sectorial compartments fixed relatively to the vane of the instrument. The next is Doodson's electrically recording current-meter. It can be lowered to any depth in the sea, and it then

measures both the speed and the direction of the current at any time, the indications being made on board.

When the current has been ascertained all over a sea, the results can be shown on charts. Fig. 4 shows the current in the Irish Sea at the time of high water at Liverpool. The full lines are *contour lines* of the sea-surface, the numbers indicating ft. above mean sea-level. It will be noticed that there is a steady fall of level from Morecambe Bay to beyond St. George's Channel, passing through mean sea level between Bardsey Island and Arklow Bank. But the currents are only flowing near to the coasts. From the slope of the water surface, however, it is clear that there is a strong tendency for the water to flow out through the main fairway. Fig. 5 shows the currents three hours after the time of high water at Liverpool, when this tendency to flow out has produced its maximum effect. The contour lines are then parallel to the currents and there is a rise of level from the Welsh coast to the Irish coast. This difference of level is produced by the rotation of the earth, which tends to pile up the water on the right of the current.

In seas such as the Irish Sea there is, at any one time and place, very little variation of tidal current between the surface and the bottom; the rise and fall of water along any vertical is proportional to the distance above the bottom. But in the open ocean and in seas where the density changes between the surface and bottom, there may be big changes of tidal current between surface and bottom. In these cases we get the phenomenon of *internal tides*, in which it is possible for a large rise and fall to take place below the surface of the sea, when there is very little rise and fall in the surface of the sea.

Cause of Tides.

A complete explanation of the physical and dynamical causes of the tides is a little difficult to understand, so I will restrict myself to a few simple statements.

The tides of the Mersey are caused by those of the Irish Sea; the tides of the Irish Sea are caused by those of the Atlantic; the tides of the Atlantic are caused by the variations in the gravitational pull of the moon and the sun on the water of that ocean. The tidal forces of the moon nearly repeat

themselves every 12 hours and 25 minutes. The tidal forces of the sun very nearly repeat themselves every 12 hours. The tidal forces of the moon and sun combined have a fortnightly inequality, and reach their maxima at new and full moon and their minima at the moon's quarters. The calculation of these forces is a straight-forward matter of astronomy and can be carried out with great accuracy.

Distribution of Tides over Seas and Oceans.

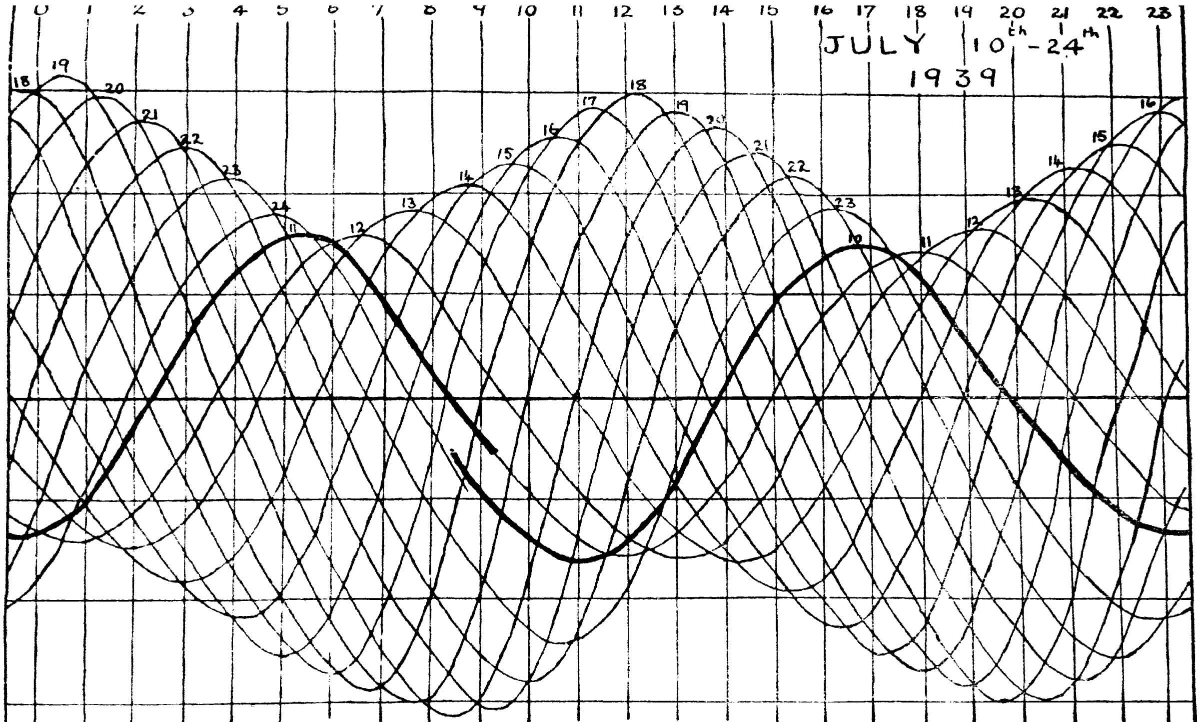
In order to specify the distribution of tides over a sea, the two most important quantities are the mean range and the mean high water interval. A *co-range line* is a line drawn through points at which the mean range is the same; a *cotidal line* is a line drawn through points at which high water occurs at the same time. In order to state this time it is convenient to use lunar hours; one lunar hour is a twelfth part of the mean tidal period of 12 hours and 25 minutes, so that one lunar hour is approximately 1 hour and 2 minutes of mean solar time. Zero lunar hour is when the mean moon crosses the meridian of Greenwich, either above or below, so that lunar time is measured by the relative motion of earth and moon in the same way as solar time is measured by the relative motion of earth and sun. Many charts of cotidal lines have been constructed during the last 120 years, and each has represented the state of knowledge at the time of its construction. In order to illustrate the difficulty of acquiring knowledge of tides away from land I shall refer, in their historical order, to several different charts for British Seas and for two of the oceans. The first charts of cotidal lines were made in 1833 by Dr. Whewell, Master of Trinity College, Cambridge, and were based on coastal observations only. His chart for British Waters shows tidal waves progressing away from the Atlantic up the English Channel and the Irish Sea, and the cotidal lines curve forward. It also shows a tidal wave progressing southwards down the east coasts of Scotland and England and northwards up the coasts of Belgium, Holland, Germany and Denmark. But the lines in the North Sea are not taken very far from the coasts. Fig. 6 shows a chart constructed in 1836, also by Whewell. The most striking feature of this chart is a point in the southern part of the North Sea from which the cotidal lines radiate. Such

a point is known as an *amphidromic* point, and the region of radiating cotidal lines is known as an amphidromic region. From the meaning of a cotidal line it follows that at such a point there can be no rise and fall of the surface of the sea ; in other words, the range at an amphidromic point is zero. A chart, produced in 1904 by R. A. Harris of the United States Coast and Geodetic Survey, shows, in addition to Whewell's amphidromic region, a region off the south-west coast of Norway from which 18 cotidal lines radiate. A chart produced by the Admiralty in 1909 shows a region from which 24 cotidal lines radiate. One produced by R. Sterneck in 1920 is based on theoretical considerations, and shows three amphidromic points. The chart shown in Fig. 7 was produced in Liverpool, the part relating to the North Sea in 1922, the part relating to the northern part of the Irish Sea in 1923, and the remainder in 1931. It shows co-range lines as well as cotidal lines, and is now a part of an Admiralty Chart. It is based on all the information available, chiefly on that relating to tidal currents, the calculations being made by A. T. Doodson. The cotidal lines have much less curvature than those of Whewell, and such as they have is as much backwards as forwards.

Considering now the Atlantic, Fig. 8 gives Whewell's chart of 1833 ; it shows a wave progressing from south to north. The next chart was produced in 1904 by R. A. Harris, and is based on a certain amount of theory ; it shows an amphidromic region in the North Atlantic and differs altogether from Whewell's in the north. The next was produced by Sterneck in 1920 ; it really consists of a connecting up of the coastal values. Fig. 9 shows both cotidal lines and co-range lines for the central part of the Atlantic Ocean. This particular chart is based on some elaborate calculations which I made in 1944, and utilises a lot of theory. It will be noticed that there is a fanning out of the cotidal lines from west to east, south of the Equator ; also that there is a trough of minimum range where the cotidal lines are crowded together. The chart of Fig. 10 was constructed in Germany, also in 1944, but was not available in this country until after V.E. Day. This chart is based mainly on coastal elevations. It will be noticed that there is an amphidromic point half way

between Ireland and Labrador, and another one between the Cape of Good Hope and Antarctica. It is a task for future investigation to see how accurate this chart is, either by the development of some means whereby the rise and fall of the tide can be measured in mid-ocean, or else by the extension of the theory by which I produced my chart.

For the Pacific Ocean we have much less knowledge than we have for the Atlantic Ocean. A chart was produced by Harris in 1904, one by R. Sterneck in 1920 and one by Dietrich in 1944 (Fig. 11). There is little real theory behind any of these Pacific Charts, and the determination of the definitive chart for the Pacific is a task for the future. Fig. 11 may be compared with the theoretical results for an ideal ocean of uniform depth bounded by a complete meridian. These are shown in Fig. 12 which was constructed by A. T. Doodson in 1937, using a mathematical method which I gave in 1916. Even this constitutes a very difficult mathematical problem.



BIDSTON OBSERVATORY — ALFRED DOCK TIDE GAUGE

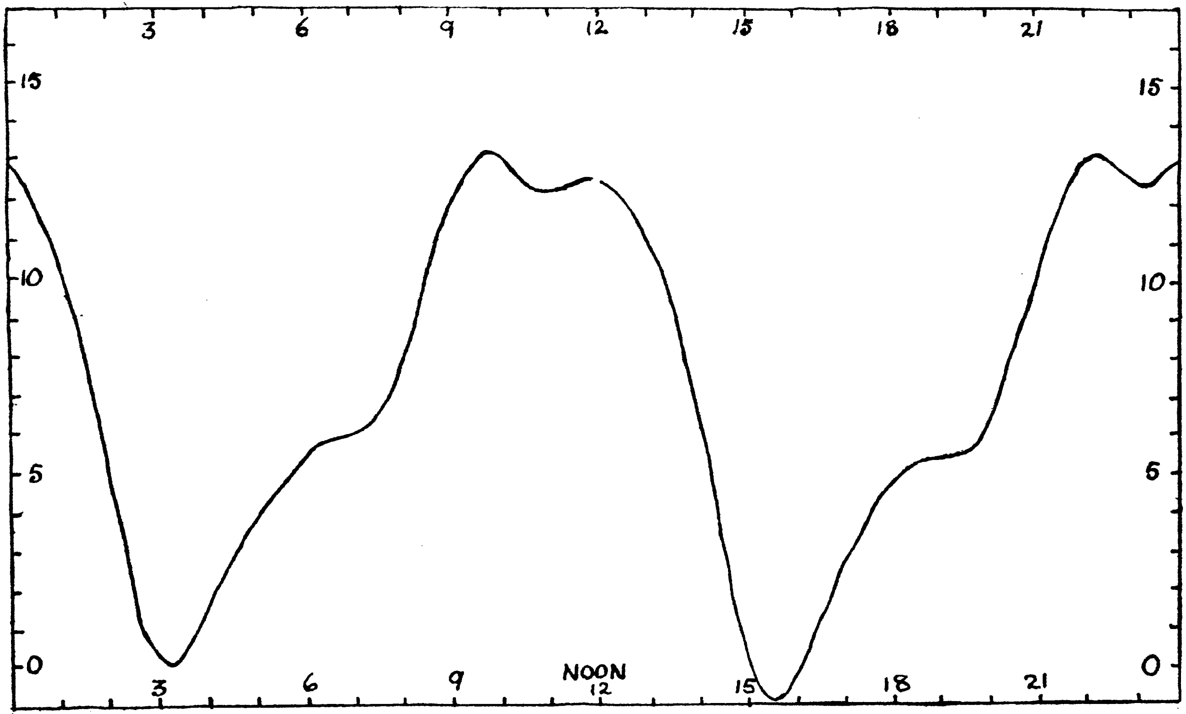
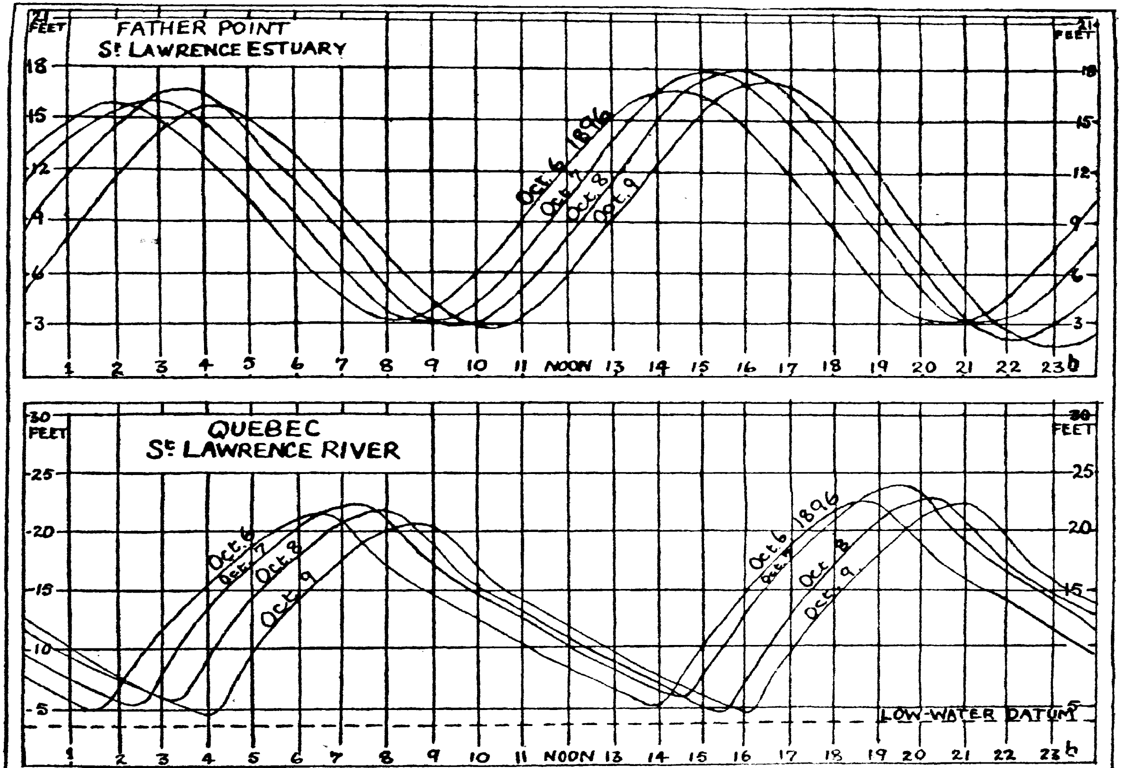


Fig. 2. Typical Tidal Record for Southampton.


FATHER POINT
St LAWRENCE ESTUARY
FEET
Oct. 6 1896
Oct. 7
Oct. 8
Oct. 9
NOON
QUEBEC
St LAWRENCE RIVER
LOW-WATER DATUM

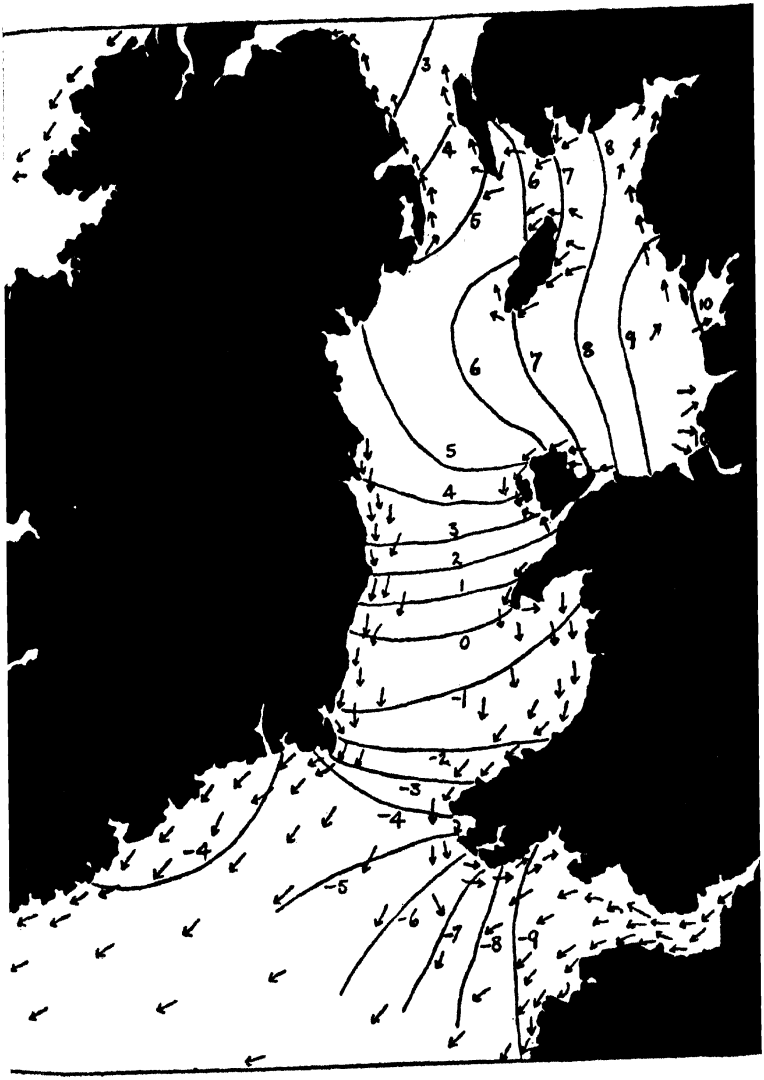


Fig. 4. Currents and Contour-Lines at Time of H.W. at Liverpool.

Fig. 5. Currents and Contour-Lines 3 Hours after H.W. at Liverpool.

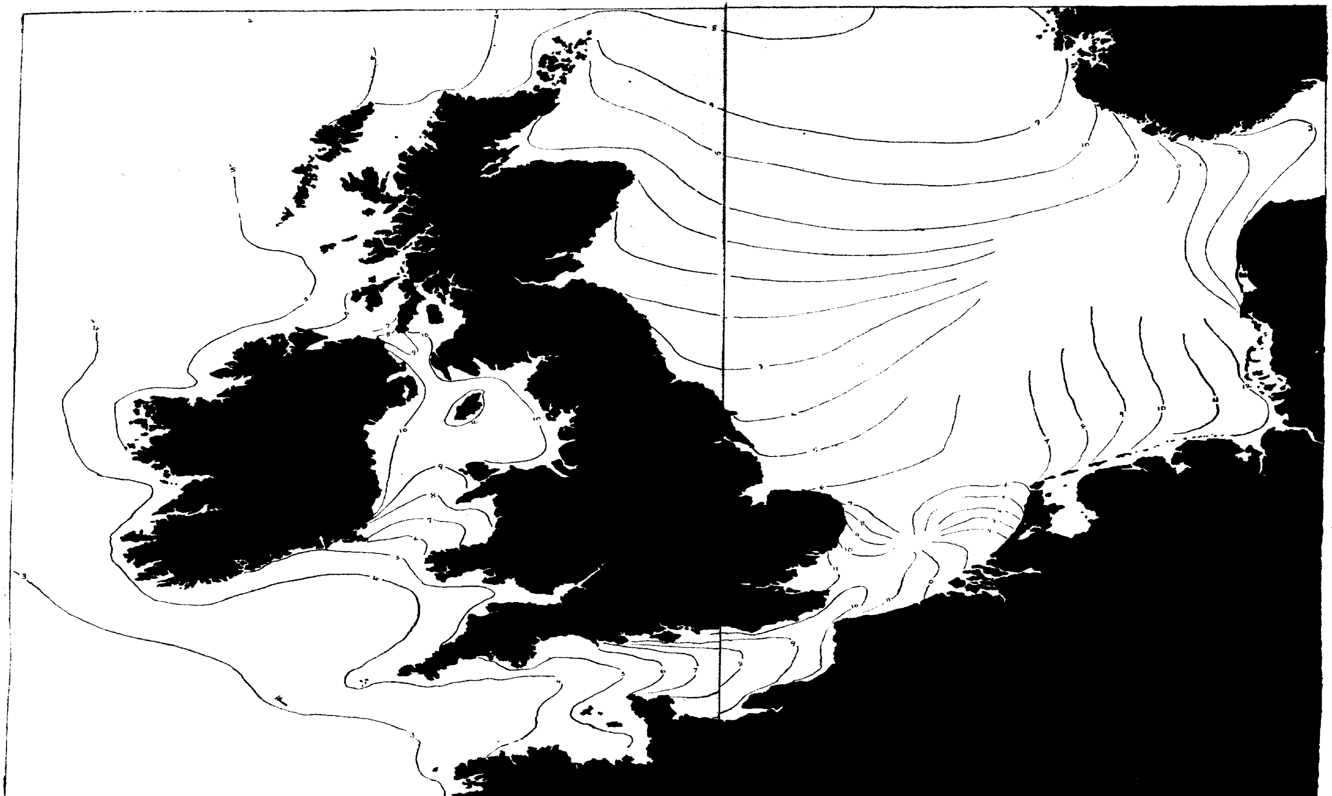


Fig. 6. Whewell's Cotidal Lines fo British Seas (1836).

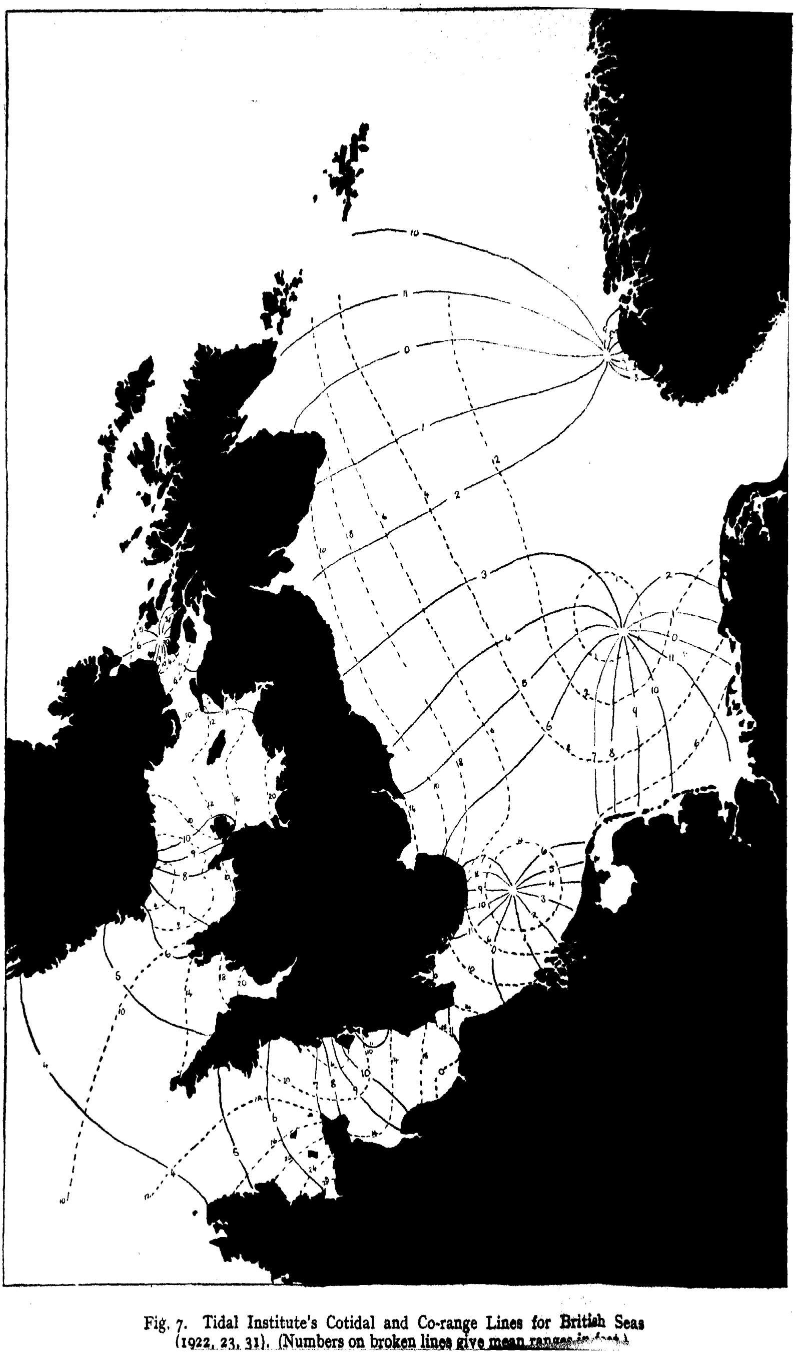


Fig. 7. Tidal Institute's Cotidal and Co-range Lines for British Seas (1922, 23, 31). (Numbers on broken lines give mean ranges in feet.)

Fig. 8. Whewell's Cotidal Lines for Atlantic Ocean. (1833).

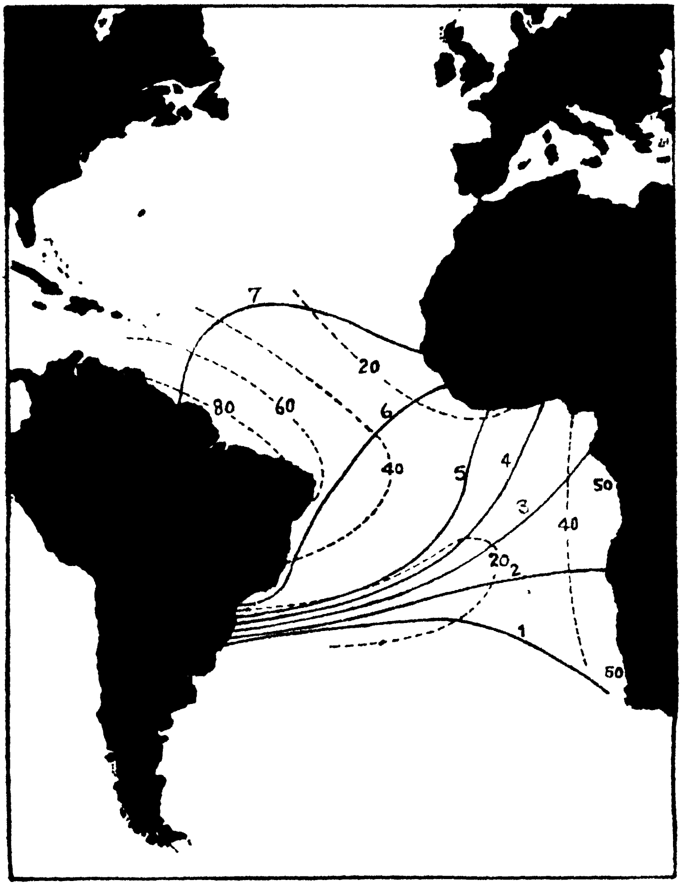


Fig. 9. Proudman's Cotidal and Co-range Lines for Atlantic Ocean (1944).
(Numbers on broken lines give half ranges in centimetres.)

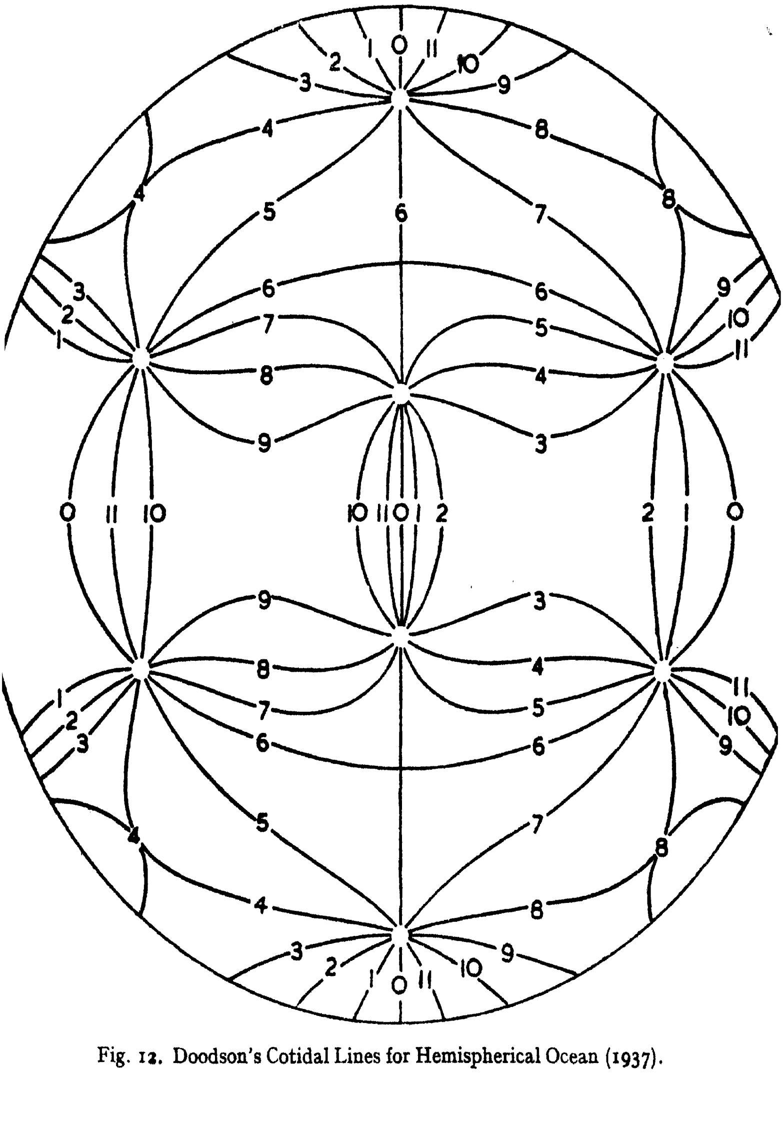


Fig. 12. Doodson's Cotidal Lines for Hemispherical Ocean (1937).

The Evolution of Society in the Middle East.

By H. S. DEIGHTON.

The problem which faces the Middle Eastern peoples to-day, is one of adjustment. In common with all oriental peoples they are confronted with the necessity for adapting themselves to the new environment created for them by the world-wide extension of Western power, ideas and technique.

At the beginning of the sixteenth century it might have seemed that the Ottoman Turks were about to achieve the aim of Justinian, to undo the work of Constantine and to unite, under a single government, the whole area around the Mediterranean which had formed the Roman Empire. The Black Sea was a Turkish lake, the Balkans, the Middle East and North Africa almost to the Atlantic, were under the control of the Sultan. A sharp deterioration in the quality of Ottoman government brought the expansion to a standstill and, by the end of the seventeenth century, the technical superiority of the European Powers, particularly in the military field, had thrown the Turks into a permanent attitude of defence, so that the historian of the Eastern Mediterranean lands during the four centuries which preceded the war of 1914—1918 might reasonably entitle his work : *The Decline and Fall of the Ottoman Empire.*

The decline in the relative strength of the Ottoman Empire and its neighbours, aptly illustrated by the well-known epigram of the Tsar Nicholas I, who described it as " the sick man of Europe ", did not for centuries greatly affect the life of its peoples. Turmoil and disaster were commonplaces of life in Constantinople often enough after the strong rule of the first Sultans had given place to the feeble venality of their degenerate successors. Away from the capital the relaxation of control showed itself in, for example, the effective independence of the North African provinces, the Barbary States of French and British history, or in the feudal anarchy of Mamluk Egypt. But for all this, the life of the people and the pattern of society remained unchanged by the decline of government or the loss of distant provinces. It was not until Bonaparte landed in Egypt, in 1797, that direct contact with the West and its ideas began to affect Middle Eastern society. Indeed, few of the

periods into which we divide the past owe their recognition and demarcation so entirely to the circumstances of the case and so little to the artifice and convenience of the historian, as does the modern period in the history of the Middle East. In every sense this may be said to have begun with the arrival in Egypt of Bonaparte, with his army and his attendant train of administrators and *savants*.

The military purpose of the expedition, which was undertaken because of the over-riding strategic importance of the area in the considerations of the great Western Powers, provoked the British into naval action and, eventually, into a policy of " vital influence " in the Middle East. The mutual rivalries of the Great Powers determined the policies of their governments from that time until the Ottoman Empire vanished from history in 1918. Meanwhile the influence of Western ideas and example was undermining the bases of Muslim life and society.

First, and most immediately potent, of these ideas was that of nationality, and its expression in the nation-state. It was this conception that provided the dissolvent of the Empire and it has been upon a basis of nationalism that its successor states have been built up. Starting among the subject Christian peoples of the Balkans and encouraged by both Russia and the Western Powers, the idea of nationality spread to the Arabic-speaking peoples further south. In 1920, it affected the Turks themselves and gave rise under Kemal to the first wholly independent nation state on the modern pattern to be found between the Balkans and Japan. The Arabic-speaking peoples of the Eastern Mediterranean hinterlands, of Iraq, Arabia and Egypt, were too much involved in the interests of other and stronger Powers to achieve unity and independence immediately after the collapse of the Turkish rule, even had they been ready or wholly conscious of a desire for it. Their mutual rivalries were many and bitter, and fragmentation appeared to be their reasonable lot. But there is a sense in which the Peace Settlement after 1918 may be said to have created Arab unity, for it was upon hostility to some of its effects, particularly to French rule in Syria and the Lebanon and to the " National Home " policy in Palestine, that there grew up that wide-spread sense of a common Arab point of view upon which the Arab

League has been built. The aims of those who control the policy of the League include both the extension of its membership and the development, by federal or other means, of the unity of Arab society. In its present form it is probably the nearest approach to the political expression of Arab nationalism that is yet possible. Arab nationalism has not been so strikingly successful as has its Turkish counterpart, in the field of practical politics, but it has achieved enough to allow of some relaxation of the attention hitherto concentrated almost exclusively upon "national" politics, and there are signs that the more serious problems which face the Middle Eastern peoples are beginning to receive a proportionate amount of attention.

The decline in the political status of the Ottoman world was accompanied by a slower but almost equally drastic change in the outlook of its Muslim subjects. The infidel Frank, usually in a position of authority, became a familiar figure throughout the Arab lands, and his ideas penetrated the thought and commended themselves to the intelligence, of a growing number of Muslims. In recent times, the difficulties of the West and more particularly its inability to avoid disastrous fratricidal wars, have done more to destroy the wide-spread desire for emulation which at one time existed. But the West, although less fully admired, is not to be avoided. Its impact has brought change to too many lives and continues to do so increasingly. The main internal problems of those countries which have so far succeeded in emulation of the West as to receive an independent expression of their nationality, are still problems of adaptation to the new world which the West has brought into being.

The Middle East is no longer the home primarily of the typical Arab of European imagination, if indeed it ever was so. Most of the Arabic speaking peoples practise cultivation in densely populated areas while an ever increasing number of them live in great urban centres such as Cairo, Alexandria, Aleppo, Basra and Baghdad. The cities grow rapidly. Cairo has already nearly two million people and in settled areas, the increase in the size of the population, due very largely to the application of Western methods of administration and social service, altogether overshadow the complementary increase in productivity.

In the country districts the region is still largely feudal in the sense that almost complete domination is exercised by an immensely wealthy land-owning class which often practises, even though it no longer legally holds, the equivalent of the medieval jurisdiction of " high, middle, and low ". In consequence of Western influence, whose more effective administrative methods have confirmed the position of the " haves " and offered them unprecedented scope for comparatively safe money-making, the rich are richer than before, while the poor, increased in number, are obliged to share a cake but little larger than that of their fathers.

Two new classes have come into being. Since the time of Muhammad Ali, in Egypt, the demand for clerks, technicians and minor officials, in government and business, has been met by the spread of educational methods of the Western type, and this has led to the growth of a substantial, although not yet very politically influential, literate middle class. While the growth of town-life, the adoption of Western techniques to manufacturing and to transport, in particular in the development of railways has given rise to a small but increasingly self-conscious industrial working class.

The education and culture of the area are no longer homogeneous. Many, although by no means all, of the ruling classes have adopted Western dress and habits, sometimes English but more usually French. These, if they are Muslims, observe for the most part, at least outward conformity with the practices of their religion. But the others, the nominal Jews and Christians among the rich, shed their past more readily and either adopt whole-heartedly an alien way of life, as many rich Copts have imitated the English, or more usually slip unhappily into that rootless and purposeless attitude to life which it is usual to associate with one sense of the word " Levantine ".

Much more susceptible than the rich to this unfruitful break with tradition are the educated middle class, who yearly increase in number. No one who has ever taken an interest in the news from the Middle East can have failed to notice the seemingly disproportionate part played by students in political life, particularly at times of crisis and change of government. This phenomenon is not confined to the area but was, until the recent

setting up of more authoritarian regimes, a characteristic of the Slav countries of the Balkans, and of Greece. In Arab Asia the students, notably those of the American University, Beirut, the source of more than half of the Arab-Asian *intelligentsia*, have played a leading part in the history of nationalism, but it is in Egypt that student interference in politics is most noticeable. Not only university, but secondary school students engage in strikes and produce a temporary paralysis of business in big cities by their political demonstrations. Governments are extremely sensitive to students or rather are apprehensive of the students' ability to make trouble. Their student policies are varying and unpredictable, so that the lecturer at Cairo or Alexandria may expect the occasional competition of a cabinet minister who will flatter and cajole an assembly of students. He must not be surprised, on the other hand, to find, at times, that the university buildings have been surrounded and occupied by a substantial military force.

Such activities are bad for education, particularly when, having brought lecturing to a stop for some weeks, they are followed by a demand for a corresponding lowering of examination standards. But it is too easy to condemn such unacademic activities out of hand. The analogy of student conduct in Britain, although no doubt it represents one ideal, does not hold good. The Middle Eastern student is justly aware that he represents a far greater proportion of his country's literate and relatively disinterested population than do his Western fellow-students. His reading and personal contacts bring constantly before him the real backwardness and needs of his people. It is true that student strikes are usually begun by small groups in the pay of whatever parties happen to be in opposition, but it is equally true, and perhaps not surprising, that they attract as the majority of their participants young men who are genuinely and understandably anxious for change, on grounds more worthy than that of personal advantage.

More serious than the political activity of the student while he is still *in statu pupillari*, is the comparative political ineffectiveness which is usually his lot after his student career is over. During the past thirty or forty years many thousands of young graduates, equipped more or less with an education of the

Western type, have gone into Arab and Egyptian society. It cannot but be said that their influence, politically and generally, upon their society has been disappointingly slight. In part this is due to the fact that there has not yet been a serious shift in the centres of power in Middle Eastern society. The effect of the impact of Western methods has been, so far, to stabilise the rule of the great landowners and to increase their economic and political power. Thus the young graduate who goes into administrative work is very largely dependent upon and subservient to the real rulers of the country. Similarly in business the small man is anxious for his position and is without serious influence. Technically, the Arabic-speaking lands have entered the twentieth century, just as they have in respect of nationality and its claims. But in internal political development no Arab land has yet seen an equivalent of the events of 1832 in Britain.

It is not surprising that the European educated middle-class Arab has not yet taken a dominant position in the life of his country. Drawn from homes which are still conservative and traditional, in many cases still from families whose heads are illiterate, they are thrown into direct and intensive contact with the new world. They epitomise in themselves the lot of their community. For them the conflict of East and West, or of old and new, provides the environment in which they must live. Uprooted from their own past, thrown into close, although usually imperfect contact with the world of Western ideas, but obliged, nevertheless, to live out their lives in a society dominated by powerful men whose attachment to the principles and culture of the West is, if it exists at all, largely superficial, they must if they are to find peace of mind, resolve within their individual lives, the great problem of cultural differences which overshadows the entire Orient. Small wonder, then, that they are often infected with the curse of Levantinism and are at root profoundly unhappy. Yet many of them are talented and technically very efficient. The quality of Egyptian doctors is recognised even by British regulations about medical practitioners, and, in irrigation, engineering and law, many of them reach very high standards. During the war many Allied military and civil organisations, notably the Middle East Supply Centre, made full use of local personnel and, even in the spheres of administration

and education (where, especially in the humanities, there is so much scope for the sort of pretentious and un-self critical posturing for which "Levantines" have a talent), it is probably the unsympathetic environment and the frank discouragement of enterprise that holds up progress. The lot of the educated *bourgeois* in Middle Eastern society is a hard one. It seems clear that it is from his ranks that leadership should come, and all the circumstances seem to combine against him. But it is far too soon to say that he will not succeed in overcoming his difficulties.

More recent than the rise of the middle-class has been the growth of the industrial working-class. As yet the workman who is not an agricultural labourer or a domestic servant is a member of a numerical minority. But, particularly under pressure of the war, industrial development has begun to be a real factor in the Middle East. In Arab Asia ever-increasing numbers are employed by the great oil concerns. In Egypt, the textile factories at Mehalla-al-Kebir employed over 27,000 hands at the beginning of the war, and a far greater number of skilled and semi-skilled workers were employed (often after training) by the Allied workshops and repair depots upon which the campaigns in the Middle East and, in part, in Italy were dependent. So substantial is this labour force, that it is likely to play an increasing part in the calculations of British military advisers with regard to Egyptian affairs. It is arguable, and is often argued by experts, that the friendly co-operation of Egyptian labour is more important to British interests than the mere garrisoning of Egyptian territory in times of international crisis.

Already the organisation of these workers is beginning, along lines marked out by Western example. The oil companies are relatively good employers. Western experience and the pressure of the governments in whose territories they operate, encourage them in this. So, too, were the Allies during the war. But the native ruling groups, accustomed to the services of an ill-paid but acquiescent peasantry on their lands, are slow to see the need for improving industrial living standards at the expense of their profits. The seeds of a social conflict may perhaps lie in this situation. Leadership of a more self-conscious and politically active working population might provide a field of real effectiveness to the politically "under-privileged" educated classes. A

significant feature of the demonstrations in Egypt, in 1946, was the sober and realistic part played in their planning and direction by mixed committees of "students and workers". It is too early yet to attempt a forecast of the future social order of the Middle East. One thing, however, may be said with some confidence. Whatever happens the Arabic-speaking peoples will have to continue to take increasing account of Western ways but they will not follow slavishly along the European path. There is now no question merely of imitation. The past is not and will not be entirely rejected. However much the technical and practical superiority of the West may continue to enforce the replacement of old methods with new, there is now no likelihood that this process will be accompanied by a wholesale adoption of Western values—whatever they may be.

The future appears to lie not with radical change but with adaptation. There is no reason for regret in this. There are respects in which the social ethics of Muslims have, at least in practice, much to teach the Western peoples. A most striking example of this is in regard to their attitude to peoples of different colour. Nor, it is becoming clear, is the traditional position of women an intrinsically Muslim, so much as an Oriental, custom. There can be no unsurmountable obstacle to the task of finding a high place for experimental science in the thought of the religion of the early Caliphates. The greatest difficulty that adapters are likely to meet is the profoundly conservative influence of Islam. But there is no shortage of serious and influential Muslim thinkers who seek to demonstrate that this characteristic is acquired by, rather than inherent in, their religion. The late Muhammed Abdu has had many followers, not the least influential of whom is the present Rector of *Al-Azhar*, the most important intellectual and educative centre of Islam. Nor should it be forgotten that the power of achieving a synthesis of cultures is one of the most marked historical characteristics of Muslims. The tradition and way of life which was able to absorb Persian and Byzantine cultures and survive, and which was able to build up the civilisation of Muslim Spain, is not necessarily endangered by the necessity for accommodating itself to the West.

Transitions in Thought and Thought in Transition.

By H. J. Fleure, F.R.S.

When the Society did me the honour of an invitation to give the first lecture in memory of our devoted honorary treasurer and ex-president, Mr. R. H. Clayton, I felt that the lecture should have special reference to the work of the society to which he gave so much of his thought and such generous material support in days of difficulty. We knew him as a distinguished business man whose vision went far beyond commercial success into the problems of maintenance of liberty and efficiency in a democratic industrial society. He hoped to see industry helping the universities, and especially his own University of Manchester, which he had served as Chairman of Convocation, to train men who could come into industry with a wide outlook to take part in administration as well as to be guides and pioneers in improvement of scientific technique, Travel, knowledge of industry and of markets in other countries, freer intercourse in foreign languages, betterment of our towns, especially through smoke abatement and the industrial improvements this could bring, occupied his mind continuously. He saw that profit-making was but a means to an end, in which we should visualise a social ideal of co-operation between all who take part in industry.

Perhaps, of all his activities, his work for our Society was one of the efforts nearest his heart. He was deeply attached to our fine old home at 36, George Street, now destroyed, and it is well known that a good deal of what was done to maintain the house was surreptitiously paid for by Mr. Clayton. The noble Common Room with its portraits of Dalton and Percival, the Newton relics that Clayton had secured, the Dalton diagrams on the staircases, the collection of journals, instruments and apparatus, the Ladies' Room downstairs which he had had decorated, the office with its memorial tablet, the Lecture Room that he wanted to extend, were all filled with memories that he cherished and with possibilities of future useful co-operation between city and university and the world of thought. As probably the last member of the Society who worked in the Common Room the evening before the end, I shared in a special

degree Mr. Clayton's distress at the loss of so valuable an element in the spiritual tradition of Manchester; and we had many talks about the future of the Society. I think he would have been actively interested in the lines of development that are appearing, and he would have urged upon us all to try to find some outward and visible sign to add to our inward and spiritual link with Manchester's history. He was much interested in the thought that perhaps Chetham's Hospital might move its school to some place better suited to the bringing up of boys, and that the historic library there might be extended, with meeting places for societies, offices and perhaps accommodation for meals and for guest lecturers in co-operation with the Cathedral authorities. It may be that this scheme must be laid aside; and it is at any rate good that our Society has secured a home in one of the good buildings of the City, but the idea of a link with such a historic centre as Chetham's Hospital illustrates Mr. Clayton's appreciation of what the Society has tried to do in its long life; it is one of the older learned societies of Britain. So far as I know only the Royal Society, the Society of Antiquaries of London, the Royal Society of Edinburgh and the Honourable Society of Cymmrodorion have serious claims to earlier foundation.

I had thought of trying to say something about the evolution of thought concerning research from the beginning of the modern scientific movement, with which our Society has had such vital connections through Percival, Dalton, Joule and many more of its members. But, when I read the Riddell Memorial Lectures given recently by our ex-President, Professor Polanyi, I realised I should be plodding across a field he had already ploughed with his usual directness of thought and plan. So my effort must be to some extent deviated.

First of all, however, let me express my whole-hearted acceptance of most of what Professor Polanyi says. The premisses of science, accepted by the community of scientific workers, the scientific conscience arbitrating between the critical procedure of the researcher and the intuitive impulses, or may one call them visions, on which scientific progress depends, need to be treasured more than ever in these days when an old obscurantism has found new channels of influence.

As it seems to me, European thought in the last 450 years or so has been experimenting along the difficult line of substituting "We seek the truth" for the older attitude "We have the truth". It is a difficult line because of the danger of anarchic disintegration in a society concerned with its own continuance and doubtful about its own stability. Polanyi's emphasis on the need for rejecting a Specific Authority giving verdicts in matters of conscience is most welcome, and so is his emphasis on the need for a General Authority upholding the ideal of conscientious devotion to the search for truth and the maintenance of that ideal even against self-interest of whatever kind. Objectivity in thought and patient hearing of divergent views lead on to active toleration which I should describe as co-operation across differences of opinion; objectivity and toleration seem of the utmost importance. Let me illustrate. Years ago, Havelock Ellis successfully argued that English life owed a great deal to certain regions which were what might be called founts of ability and we might consider two of these a little further. Along the Welsh border one finds that Welsh family names are very common, and that indicates the migration of people, in a generally quiet fashion, from the Welsh valleys down to the more open Border lowland. One also finds a fair number of English family names on the Welsh side of the border. A survey made over a period of nearly 30 years at the University College of Wales, Aberystwyth, showed that, of men students who, after College, did something distinguished in some field of activity or other, a surprising number came from the two sides of the border, from the district that, on the English side, stretches from Ludlow to north of Wrexham. Study of a number of individual cases showed, further, that most of them had the faculty of putting themselves, mentally, on either the English or the Welsh side and of looking at the other side critically, even humorously, usually with a rather sympathetic touch. They have, one might say, one foot in each tradition, and I should claim that this is a large factor of their usefulness in the world. The people who are entirely immersed in one way of life need to make a great effort to see things in valuable perspective when they meet other heritages; some with special vigour do it, many find themselves limited.

One thinks of many anecdotes of British or French people finding themselves in foreign countries ; sometimes the situation is merely humorous, sometimes it is almost disastrous.

The other case from Havelock Ellis is that of East Anglia. If one studies the traditions of field systems there, and along with this the character of the local manors, one finds that manor and township do not coincide so often as they do in parts of the English Midlands, where the open fields and strips were spread by the post-Roman invaders of that land which they found with only very few people. In East Anglia, and Kent, they found a field system, a scheme of cultivation that the Romans in their turn had to some extent continued from Belgic and perhaps even somewhat pre-Belgic times. The fields were enclosed and open fields with strips were a minor feature. Manors were small and parts of a township might be in different manors. Apparent persistence of the system through Danish and Norman times suggests its momentum, though we lack pre-medieval documentary evidence. But what is still more important is that East Englia received Flemish weavers and religious refugees, and, later on Dutch drainage engineers. We thus have here again as on the Welsh border people of diverse heritage living side by side and intermarrying. There is the interplay of outlooks and the objectivity that results from it. There is here also the direct importation of ideas of drainage and of root crops in the fields, and in both cases incoming peoples found economic opportunity ; that is a factor not to be overlooked.

If reference has been made to tradition and to the danger of its fossilisation, that by no means suggests an undervaluation of certain aspects of tradition, it implies rather its enrichment by the addition of an interest in diversity and of a tendency to discuss rather than to suppress difference of opinion.

One might I think argue that people of Jewish descent who mix freely with their non-Jewish neighbours in a social system of which they feel themselves to be members produce a high percentage of marked ability, especially, in this case, in interpretation. Musical performance, drama, politics, finance are all noteworthy lines of chosen action.

May I now ask you with these thoughts in mind to follow some lines of development that concern the birth of our Society? The persecuting enthusiasms of the medieval church led refugees to Holland, where, in the sixteenth century, initiative rose to a remarkable height. Windmills were adapted to pumping water off the land, new-drained land was used at any rate early in the seventeenth century for new purposes, namely the growing of root crops on a field scale; and soon came their utilisation for winter fodder which improved the quality of the farm animals and so of the protective elements in men's food. The Dutch improved sailing ships and began to make a commercial focus.

Alongside of these initiatives in economic life one finds a remarkable intellectual activity. Spinoza descended from refugees, Descartes, himself a refugee, Huyghens and Leeuwenhoek in science, Grotius' system of international law, and most of all the great constellation of painters, perhaps the greatest that has occurred in Europe and the most worthy to be set beside the Sung group of painters in China. And how often they paint ordinary people and towns, houses and scenes for their own sake, not as accessories to a mythological idea or because the person painted was some ruler to be flattered.

The brilliant blossoming of Holland faded to some extent as commercial wealth increased beyond measure, a matter that suggests partial analogies with Victorian England; but probably a more important factor of the fading was the stress of war, and perhaps also the draining off of a good deal of ability to other places. One thinks of van Dyck and Lely coming to England, of the Dutch help to the Great Elector in building up the future Prussia by making a beginning of its canal system, of the founding of New Amsterdam, where names such as Roosevelt, Vanderbilt, Yonkers and many others give a good indication of what went on. Yet, in this twentieth century, Holland is still well to the fore in many respects, perhaps the best educated country of all, and her regard for toleration has long been a marked feature though there have been limitations at times.

What concerns us primarily here is the rise of the habit of seeking the truth by enquiry and more or less free argument.

In England, the seventeenth century saw partial efforts in the same direction, and the fact that Scotland had undergone a different metamorphosis at the Reformation, and yet was placed in relation with England, through providing England with a king, made in the end for a measure of toleration. The king must link himself with both the Anglican and the Scottish Church; Anglicanism is a form of dissent in Scotland! Jeremy Taylor and his group at the Restoration of 1660 pleaded wonderfully for toleration and condemned party autocracy in thought. Another important factor in our case was the coming of Huguenot refugees, affiliating themselves to dissenting communities of solid, often intellectual, people in industrial centres, especially such as did not have a mayor and corporation, as dissent was subject to special persecution and restriction in boroughs. These communities split again and again in discussions on what now seem very small matters, but it is not proper to deal with their differences in this Society. What is relevant and important is that quite a number of rival orthodoxies, if one may so speak, came into existence and this had important consequences.

In the first place it diminished persecution, in the second place it promoted thought, which, in the 18th century, went beyond what would have been considered permissible limits in the 17th, in the third place it encouraged education among the dissenting groups increasingly concerned with the clash between scholastic theology and the fuller view of the world developing through the inspiration of Copernicus, Galileo, Huyghens and Newton, as well as of Columbus and Prince Henry, Vesalius and Harvey, Bruno and Spinoza.

Sectarianism was at the time unfortunately dominant at Oxford and Cambridge, and this meant the exclusion of non-Anglicans, who therefore had to found academies outside the old universities. Features of these academies' work were the relative prominence given to mathematics and science, the study of philosophical systems not as yet considered at the old universities (Locke especially) and the use of English rather than Latin in teaching. They also tried to give intending ministers a fairly serious course in Hebrew. The Academy at Carmarthen in South Wales has had many vicissitudes but is

still active there. Our member, Dr. McLachlan, has on various occasions told the Society about the efforts of Warrington Academy and the foundation at Manchester which has in the end become Manchester College, Oxford. The group concerned gathered around Cross Street Chapel and gained strength through the presence of Joseph Priestley for a few years.

To understand a little more fully the atmosphere in which this Society crystallised out, it is useful to draw attention to some contrasts between English and French life at the time. In England the authority of the central administration was of long standing and strong enough to leave a good deal of power in the hands of local authorities. On the religious side the Anglican Church was an uneasy compromise between medievalism and the reformation, and the many dissenting groups made persecution less rigorous than it was in France.

In that country, centuries of struggle between the kingdom and the scarcely lesser dukes and counts, and also the Plantagenets, had emphasised the central power which Richelieu and Louis XIV found means to develop still further. To this day the mayor of a French Commune is in theory an officer of the state. Early in the struggle the heretical views of the Albigenses, over whom the kingdom wished to rule, made loyalty to the medieval church a test of French citizenship, and all attempts to mitigate this party autocracy failed, persecution of the most savage kind being applied again and again. The effort to have a Specific Authority in thought coloured the development of the Sorbonne, at the centre again. Note the contrast over against Oxford and Cambridge at the sites of the great fairs, one between Midlands and South (S. Giles') and one between Midlands and East Anglia (Stourbridge at Cambridge), each with a Norman motte-and-bailey castle. In France, long and harsh suppression led to the far-reaching outburst under Voltaire and his contemporaries, a very radical movement of opinion against the degenerate *ancien régime* in state and church. The men who tried to find a middle way were eliminated and the party autocracy went on to its doom, with its sceptical critics more and more active and denunciatory.

In Britain, on the other hand, the more radical thought hardly found expression until the days of David Hume and Tom Paine. Attention was focused rather on all sorts of efforts to find a middle way—intellectual efforts among the early Dissenters and their descendants, more emotional and more elaborately organised reactions being prominent among the Nonconformists, who came into existence in the second half of the eighteenth century and gathered around the genius of John Wesley. Priestley's group, in the intellectual tradition, naturally had its connections with French critical thought, but was less concerned to substitute one party autocracy for another and more anxious to work for toleration, as Thomas Jefferson's Statute of Religious Liberty for the State of Virginia drafted in 1775 and his friendship with Joseph Priestley and Tom Paine abundantly testify.

It was after Priestley's departure that the group gathered around Thomas Percival in Manchester and in 1781 founded our Society, to discuss freely problems of thought, eschewing references to religious and political controversies. One sees in this the growing conviction that loyalty to disinterested research into nature was an ideal transcending diversities of opinion, and Priestley's contribution to the understanding of oxygen is very significant here, as is the use of the chapel room at Cross Street for the early meetings of the Society. It would be a generous recognition of the long struggle for freedom of discussion if the Society could hold a meeting occasionally in that room.

The metamorphoses of the Society in its 166 years of life are understandable in the light of the further evolution of thought. Many general discussions are reported, including some on educational schemes which led on to the foundation of mechanics' institutes and thence to such institutions as Colleges of Technology; and there are glimpses of the interesting and important personality of Robert Owen. The group's spectacular achievement was, however, to bring John Dalton to Manchester with the result that the Society became associated with his pioneering work in atomic chemistry, in colour vision, and in meteorological measurement. He seems to have set the tone of the Society for many years and naturally encouraged efforts towards measurement, verificatory experiments

and the more scientific outlook so far as it was understood in his circle. It is rather amusing, in the light of modern knowledge, to find that Dalton appears to have thought the amount of carbon dioxide in the atmosphere could be interpreted as an accumulation from animal respiration during the, nearly, 6,000 years since the creation of the world ; plant assimilation of this gas he seems not to have accepted. One accordingly finds disciples trying to get a more accurate estimate of the amount of carbon dioxide in the atmosphere. Whether their efforts had value I shall not presume to judge.

Dalton died in 1844 and in that decade and the next large changes of thought were on the way. The majesty of the idea of seeking the truth, in faith that there was truth to be sought, attracted men of great intellectual and moral stature. I need mention only Lyell, Darwin, Huxley, Faraday in Britain. And to suggest the quality of these men I shall add a point about Darwin. He read Lyell in 1831 and went for his voyage on the Beagle. Notes here and there suggest the trend of his thought, which took shape especially 1837–39 after his return. Then, in 1842, he wrote the famous manuscript sketch found in a cupboard in 1896, and a further elaboration in 1844. The 1842 manuscript concludes with his vision of " life . . . under one or a few forms from which, whilst our planet has gone circling on according to fixed laws and land and water have gone on in a cycle of change, replacing each other, through the process of gradual selection of infinitesimal changes, endless forms . . . have been evolved ". The great vision was there, the sorting of the details followed ; the Origin of Species appeared in 1859 and Darwin actually says, in the second paragraph of the book, that Lyell and Hooker honoured him " by thinking it advisable to publish, with Mr. Wallace's excellent memoir, some brief extracts from his manuscripts ".

With men of that moral stature it is no wonder that the prestige of research was rising ; and no doubt technical applications such as the steamboat and railway engine and soon the iron ship and much besides added to that prestige with the general public.

Meanwhile, the Royal Society was organising its present system of departmental committees for scrutinising candidatures,

and the scientific societies generally were expanding rapidly. Our Society came under the influence of Joule as Dalton aged and died, and for a number of years it tried to provide a place of discussion of results of research and means for their publication. But, in this long continued effort, the Society was seriously hampered. Results of research have been increasingly published in special journals devoted to a particular field of study, papers in a more general journal are lost. The English national scientific journals, one must not quite say British, were naturally published in London, where these societies were mostly sited. Publication and discussion therefore tended to drift away from Manchester, though our Society's Memoirs have a paper of some importance here and there. In the years when this phase was declining, there was a tendency to use our Society's Memoirs to publish rapidly short preliminary notes with a view to securing recognition of priority in some scientific achievement. Papers read in title only were frequent, and the Society was living on its past, while trying to help contacts between the University and the scientific technicians of the business world. These two were at the same time making direct contact with one another, and the Society was in danger of becoming a superfluous extra in the matter. The old name "Literary and Philosophical" was for a time almost disregarded. The newer 20th century personnel, of whom I may mention two active officers no longer with us, R. H. Clayton and W. B. Wright, tried to restore the Society by making 36, George Street more of a focus, by encouraging diverse groups to meet under the ægis of the old society, by restoring the idea of papers on literary and philosophical subjects alongside of those on detailed research in experimental or observational science.

And now, when science and conscience are challenged by revivals of the medieval idea of party autocracy, with accompaniments in both cases of incitement to cruelty and of obscurantist efforts to justify prejudice, the Society seems once more active in its great work as one of the pioneer defenders of freedom. Its former work of publication of scientific detail is done elsewhere, but it will not for this cause eschew science, I feel sure.

The fractioning of science is inevitable for progress of knowledge, and yet it has its dangers if one group of workers becomes isolated from another, which may be looking at what turns out to be the same problem from a different view-point. No subject is isolated. Can our Society help in this matter? I think it might perhaps arrange from time to time for one, or a small group, of its members to prepare a review, in as general terms as are practicable, of the state of knowledge on some field of enquiry. A little while ago Zeuner published a very useful book of this kind called *Dating the Past*, a study of recent advances in the chronology of the earth and of mankind. There is special value in such work, and its publication in journals of many societies is not easy, especially if it has aspects in different scientific fields. In fields of study that my work has touched I know how valuable a book on *Men between the Tropics* could be. Problems of climate in relation to men's physical characteristics and well being, problems of soil conservation and destruction, of food quality and especially quality in vitamins, relations of all this to social structure now in the grip of change following increased contact with modern commerce —all these interlock in many ways. It is very probable that there is not a member of the Society particularly active in this field, and that is a reason why I have chosen it as an example. Let it be far from me to presume to suggest what subjects should be chosen. I merely put out the idea of occasional publication of, I think, separate monographs in addition to articles in our memoirs. Another field of work that needs more attention is that of the history of scientific problems; the study of that history often gives important clues and may also help the teacher of the subject concerned. How Darwin came to develop his thought is one of the most interesting clues to many of the hypotheses he helped to create.

Keeping in touch with scientific progress in a broad way alongside of philosophical enquiry and reflection, and the study of literature in its relation with the development of thought offer scope for our society to go on in full devotion to the ideal of truth which was the mainspring of the spiritual efforts of its founders.

The moral failure of medievalism, of the *ancien régime* in France, of the Tsardom, of Hitler's and Mussolini's efforts all point to the conclusion that freedom of conscience is invaluable, not merely to avoid the horrors of persecution and the incitements to cruelty so conspicuous in all the schemes just named, but to ensure that vitality of thought and adjustment shall be maintained. It is perhaps the cumulative character of research that gives it its special social value, and such a society as ours can work towards keeping the fountain of freedom clear and the crystal stream flowing for the healing of the nations.

PROCEEDINGS OF THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Session 1946–47.

Ten Ordinary Meetings were held during the session, at which lectures were delivered as follows :

1946.

Oct. 4th.	"Naked-Eye Astronomy", by Dr. R. d'E. Atkinson, Ph.D.
Oct. 30th.	"Archery", by Mr. H. Ingo Simon.
Nov. 18th.	"The Tides", by Professor J. Proudman, F.R.S. (Wilde Memorial Lecture.) (Published *Memoir* 6, Vol. lxxxviii.)
Nov. 25th.	A Symposium on "Industry and Education".
Dec. 11th.	"Natural Philosophy and the Fine Arts", by Mr. F. I. G. Rawlins, F.Inst.P. (Published *Memoir* 5, Vol. lxxxviii.)

1947.

Jan. 20th.	"Lighting and Spark Discharges", by Professor J. M. Meek, D.Eng.
Feb. 3rd.	"Hyperbolic Navigational Charts", by Mr. Norman Pye, M.A. (Published *Memoir* 4, Vol. lxxxviii.)
Feb. 17th.	"Transitions in Thought and Thought in Transition", by Professor H. J. Fleure, F.R.S. (Clayton Memorial Lecture.) (Published *Memoir* 8, Vol. lxxxviii.)

PROCEEDINGS.

Mar. 18th. " Historic St. Andrews and its University ", by Professor J. Read, F.R.S.

Mar. 19th. Conversazione—Whitworth Art Gallery.

There were no meetings of the Chemical Section.

There were 9 meetings of the Social Philosophy Section.

The ANNUAL GENERAL MEETING was held on April 29th, 1947, in the Council Chamber of the Manchester College of Technology.

ANNUAL REPORT OF THE COUNCIL, APRIL, 1947.

Membership.

During the session 1946–47, twenty-six new members were elected, bringing the total up to 195, including ten Life Members. There were eleven resignations during the session.

The Council regret to record the death of :

R. H. Clayton, on August 12th, 1946, for 25 years Hon. Treasurer of the Society.

W. Coventry, on May 18th, 1946, for 6 years Asst. Secretary of the Society.

D. M. Paul, on January 24th, 1947, for 18 years Hon. Secretary of the Chemical Section.

Meetings.

The Annual General Meeting was held in the Council Chamber of the Manchester College of Technology on May 29th, 1946, when Professor T. B. L. Webster was elected President of the Society.

The Wilde Memorial Lecture was held on November 18th, 1946, in the Reynolds Hall of the Manchester College of Technology, and was given by Professor J. Proudman, F.R.S., Professor of Oceanography, Liverpool University, on "The Tides".

The Council proposes that a Clayton Lecture should be given (if possible annually) as a tribute to the devoted service of R. H. Clayton, and the first Clayton Memorial Lecture was held on February 17th, 1947, in the Reynolds Hall. It was delivered by Professor H. J. Fleure, F.R.S., Vice-President of the Society, who took as his subject "Transitions in Thought and Thought in Transitions", and spoke with special reference to the Manchester Literary and Philosophical Society, 1781—1947, and the work of R. H. Clayton for the Society.

An informal reception at which eighty-two members and friends were present was held at the Whitworth Gallery on March 19th, 1947.

Details of other meetings will be found in the record of Proceedings.

Council Meetings.

Six Council Meetings were held during the session.

On behalf of the Society the Council tenders its thanks to the authorities of the University of Manchester and the Manchester College of Technology for their kindness in allowing the use of their rooms for lectures and Council Meetings.

Dr. Thomas Percival Lectureship.

The first lecture was given by Professor C. W. Wardlaw at the University on February 11th, 1947, on " Process and Record : Aspects of Botanical Science ", and was preceded by a tea at which members of the University and the Society were present.

Portrait of John Dalton.

A replica of the portrait in oils of John Dalton, formerly in the Society's building which was destroyed by enemy action, has been painted and is now hung in the Entrance Hall of the Central Library by kind permission of the Library Committee.

The Library.

It has been decided that the remains of the Society's Library, together with books and journals received since the destruction of the Society's premises at George Street, shall be deposited in a special collection at the Central Library, Manchester. This arrangement is now in force, and members of the Society may consult books and journals in this special collection—other than current journals which are retained for a period in the Portico Library.

Portico Library.

The Council wishes to place on record, on behalf of the Society, its appreciation of the co-operation of the authorities of the Portico Library in reaching an agreement whereby the Portico Library, Mosley Street, Manchester, has been for the session 1946–47 the home of the Society. The arrangements, briefly given below, are renewable for the ensuing session.

1. Journals received by the Society are displayed in the rooms of the Portico Library for a month, after their receipt. They may be consulted by members between the hours of 10 a.m. to 12-30 p.m. and 2-30 p.m. to 5 p.m. every weekday except Saturday. The Library is not open to members of the Society between 12-30 p.m. and 2-30 p.m.

2. A room is available for Council Meetings, Committee Meetings, and Section Meetings of the Society after 3-30 p.m.
3. The Secretary of the Portico Library is also the Assistant Secretary of the Society. Miss J. Tyrer has been appointed to this position.
4. All communications to the Society should be addressed to the Portico Library, 57, Mosley Street, Manchester, 2. (Telephone No. CEN. 6785.)

Treasurer.

The Council regrets to record the death of its Hon. Treasurer, Mr. R. H. Clayton, and desires to express its thanks, on behalf of the Society, to Mr. H. Hayhurst, who has been filling the position of "Acting Honorary Treasurer" since Mr. Clayton's death.

Secretaries.

The Council regrets the resignation of Mr. R. D. Waller and Mr. J. T. Kendall, and desires to place on record its gratitude to them.

Accounts.

An audited financial statement is attached, together with particulars of assets and liabilities.

Gifts.

The Council expresses the Society's thanks to the donors of the following gifts :

Memoirs and Proceedings—Vols. 68 to 86 inclusive from Mr. H. Hayhurst ; Vols. 84 and 85 from Mrs. L. Hayhurst ; Vols. I to X Fourth Series, and Vols. XLI to LX inclusive from Mrs. Newell.

"The Helm Wind of Crossfell 1937-39" by Gordon Manley.

"The First Christian" by Yelverton Dabern.

MANCHESTER LITERARY

H. Hayhurst, Treasurer, in Account with the

GENERAL

	£	s.	d.	£	s.	d.
To Cash in Treasurer's Hands, April 1st, 1946...				12	19	9½
,, Members' Subscriptions :—						
Full Rate Arrears	3	3	0			
,, ,, 1946–47...	159	12	0			
,, ,, 1947–48...	3	3	0			
				165	18	0
,, Dividends :—						
Great Western Railway Company's 5 % Consolidated Preference Stock... ...	33	13	9			
East India Railway Company's 4½ % Annuity Class A...	3	18	4			
£300 3½ % War Stock	10	10	0			
£75 3½ % War Loan	2	12	6			
£250 Defence Bonds	7	10	0			
				58	4	7
,, Sales of Publications				28	19	8
,, Refund of Income Tax, 1944–45	34	6	6			
,, ,, ,, ,, ,, 1945–46	31	5	0			
				65	11	6
,, Transfer from Wilde Fund				438	4	0
,, Cash transferred from Wilde Fund for part cost of replacement of John Dalton portrait				81	0	0
,, Balance due to Bankers...				505	17	6
				£1,356	15	0½

AND PHILOSOPHICAL SOCIETY.

Society, from April 1st, 1946, to March 31st, 1947.

FUND.

	£	s.	d.	£	s.	d.
By Balance due to Bankers...				355	3	10
,, Charges on Property :—						
Chief Rent (Net) and Income Tax Sch "D"	12	18	2			
,, Office Expenses	1	15	0			
				14	13	2
,, Administrative Charges :—						
State Insurance	1	1	1			
Telephone	3	9	4			
Printing and Stationery (see Note B) ...	612	19	10			
Lecturers' Expenses and Fees...	29	9	11			
Postage and Carriage	21	11	1			
Miscellaneous Expenses	6	0	10½			
Hire of Rooms	19	4	6			
				693	16	7½
,, Portrait of John Dalton (see Note A)				131	0	0
,, Half year's Salary to Widow of late Assist. Secretary				75	0	0
,, Donation to Whitworth Art Gallery				10	10	0
,, Honorarium to Accountant				26	5	0
,, Catering at Reception				14	17	0
,, Subscription to Societies :—						
North-Western Naturalists' Union... ...	0	14	0			
Ray Society	2	2	0			
Pre-historic Society	1	1	0			
Palæontographical Society	1	1	0			
Lancashire and Cheshire Fauna Committee	0	10	6			
Royal Entomological Society	2	2	0			
				7	10	6
,, Bank Charges and Cheque Book				15	19	3
,, Cash in Treasurer's Hands				11	19	8
				£1,356	15	0½

NOTE A.—A donation of £50 towards the cost of the Dalton portrait was received from I.C.I. Ltd. per Lord McGowan and recorded in the 1944–45 accounts. The balance has been provided from the Wilde Fund.

NOTE B.—The item of £612. 19s. 10d. for Printing and Stationery includes £131. 15s. 6d. for Volume 86 and £395. 7s. 6d. for Volume 87 of Memoirs and Proceedings.

WILDE ENDOWMENT FUND, 1946–47.

	£	s.	d.		£	s.	d.
To Balance at Bank, April 1st, 1946	530	17	7	By Salary of Assistant Secretary	150	0	0
,, Cash in Treasurer's hands	17	13	4	,, Wilde Lecturer's Fee and Expenses	11	1	6
,, Dividend on £7,500 Gas Light and Coke Company's Ordinary Stock	206	5	0	,, Transfer to General Fund	438	4	0
,, Interest on £400 3 % War Stock 1955–59	6	12	0	,, Cash in Treasurer's Hands	—		
,, Refund of Income Tax, 1944–45	193	10	0	,, Cheque Book	0	8	4
,, ,, ,, ,, 1945–46	193	10	0	,, Cash transferred to General Fund for part cost of replacement of John Dalton portrait	81	0	0
				,, Cash at Bank	467	14	1
	£1,148	7	11		£1,148	7	11

BUILDING FUND, 1946–47.

	£	s.	d.		£	s.	d.
To Balance at Bank, April 1st, 1946	189	2	4	By Balance at Bank, April 1st, 1947	239	8	11
,, Interest on £700 Funding Loan 4 % Stock	28	0	0				
,, Interest on £400 3 % War Stock, 1955–59	12	0	0				
,, Bank Interest	10	6	7				
	£239	8	11		£239	8	11

JOULE MEMORIAL FUND, 1946–47. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Dividend on £100 East India Railway Company's 4½ % Annuity Class A Stock	3	18	4	By Cash transferred to General Fund	14	8	4
,, Interest on £300 3½ % War Stock	10	10	0				
	£14	8	4		£14	8	4

NATURAL HISTORY FUND, 1946–47. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Dividend on £1,225 Great Western Railway Company's 5 % Consolidated Preference Stock	33	13	9	By Cash transferred to General Fund	33	13	9
	£33	13	9		£33	13	9

SIR JOSEPH LARMOR FUND, 1946–47. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Interest on £250 Defence Bonds	7	10	0	By Cash Transferred to General Fund	7	10	0
	£7	10	0		£7	10	0

Statement relating to the Society's Property as on March 31st, 1947.

Liabilities.	£	s.	d.
Amount due to Bank on General Account	505	17	6

Income Tax: A claim for repayment of income tax in respect of the year 1946–47 is in course of preparation and will be forwarded to the Inland Revenue.

Loss as a result of enemy action: The claim in connection with the contents of the House and Library which was situate at George Street, Manchester, has been settled at £20,833. This amount has not been paid to the Society and no information is available with regard to the date on which payment will be made. Interest accrued due to the Society in respect of the above figure amounts to £3,265 at March 31st, 1947.

The claim in respect of the Society's property which was situate at 36 George Street, also 21 Back George Street, Manchester, has not been settled.

Assets.	£	s.	d.	£	s.	d.
Arrears of Subscriptions, 1944–45	2	2	0			
,, ,, 1945–46	13	13	0			
,, ,, 1946–47	33	12	0			
				49	7	0
Cash Balance :—						
In Bank, Building Fund	239	8	11			
,, ,, Wilde Fund	467	14	1			
,, Treasurer's hands	11	19	8			
				719	2	8
				£768	9	8

Investments :—

£7,500 Gas Light and Coke Company's Ordinary Stock (W.E.F.) ... ...
£400 3 % War Stock, 1955—1959 (W.E.F.) ... ...
£700 4 % Funding Loan (B.F.)... ... ...
£400 3 % War Stock, 1955—1959 (B.F.) ... ...
£100 East India Railway Company's 4½ % Annuity Class A (J.M.F.) ... ...
£300 3½ % War Stock (J.M.F.)... ... ...
£1,225 Great Western Railway Company's 5 % Consolidated Preference Stock (Nat. Hist. F.) ... ...
£75 3½ % War Loan Stock, 1929–47 (G.F.) ... ...
£250 Defence Bonds (Sir J. Larmor F.) ... ...
Market Value at March 31st, 1947, £11,895.

NOTE.—The Treasurer's Accounts of the Session 1946–47 have been endorsed as follows:

April, 1947, Audited and found correct.

We have seen the Banker's certificate that they hold £375 3½ % War Loan Stock ; £75 Certificate No. 77/19724/7 ; £300 Certificate No. 82/49566. £400 3 % War Stock 1955–59 : Certificate No. 41/397579. £400 3 % War Stock 1955–59 : Certificate No. 41/397580. £250 3 % Defence Bonds : Bond Book No. X. 751740. £1,225 Great Western Railway Co. 5% Consolidated Preference Stock : £100 Certificate No. 31794 ; £1,000 Certificate No. 31792 ; £125 Certificate No. 31790. £7,500 Gas, Light & Coke Company Ordinary Stock : £5,500 Certificate No. 340891 ; £2,000 Certificate No. 347456. £100 East India Railway Company 4½ % Annuity Class A Stock : Certificate No. 25656. £700 4 % Funding Stock 1960–90 : £500 Certificate No. 34185 ; £200 Certificate No. 23/3457. One sealed parcel marked A. One sealed parcel marked B. One sealed envelope "Papers re 21 Back George Street". One sealed envelope marked "Board of Trade Deferment Notice". One locked cash box marked "Dalton Medals, etc.".

We have verified the balances of the various accounts with the banker's pass books.

(*Signed*) A. McLEAN RANFT.
G. N. BURKHARDT.

April, 1947.

THE WILDE LECTURES.

1897\. (July 2.) "On the Nature of the Röntgen Rays." By Sir G. G. STOKES, Bart., F.R.S.

1898\. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S.

1899\. (Mar. 28.) "The newly-discovered Elements; and their relation to the Kinetic Theory of Gases." By Professor WILLIAM RAMSAY, F.R.S.

1900\. (Feb. 13.) "The Mechanical Principles of Flight." By the Rt. Hon. LORD RAYLEIGH, F.R.S.

1901\. (April 22.) "Sur la Flore du Corps Humain." By Dr. ELIE METCHNIKOFF, For. Mem.R.S.

1902\. (Feb. 25.) "On the Evolution of the Mental Faculties in relation to some Fundamental Principles of Motion." By Dr. HENRY WILDE, F.R.S.

1903\. (May 19.) "The Atomic Theory." By Professor F. W. CLARKE, D.Sc.

1904\. (Feb. 23.) "The Evolution of Matter as revealed by the Radio-active Elements." By FREDERICK SODDY, M.A.

1905\. (Feb. 28.) "The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." Dr. D. H. SCOTT, F.R.S.

1906\. (March 20.) "Total Solar Eclipses." By Professor H. H. TURNER, D.Sc., F.R.S.

1907\. (Feb. 18.) "The Structure of Metals." By Dr. J. A. EWING, F.R.S., M.Inst.C.E.

1908\. (March 3.) "On the Physical Aspect of the Atomic Theory." By Professor J. LARMOR, Sec.R.S.

1909\. (Mar. 9.) "On the Influence of Moisture on Chemical Change in Gases." By Dr. H. BRERETON BAKER, F.R.S.

1910\. (Mar. 22.) "Recent Contributions to Theories regarding the Internal Structure of the Earth." By Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

SPECIAL LECTURES.

1913. (Mar. 4.) "The Plant and the Soil." By A. D. HALL, M.A., F.R.S.

1914. (Mar. 18.) "Crystalline Structure as revealed by X-rays." By Professor W. H. BRAGG, M.A., F.R.S.

1915. (May 4.) "The Place of Science in History." By Professor JULIUS MACLEOD, D.Sc.

DALTON MEMORIAL LECTURES.

1931. (Mar. 17.) "Atoms and Electrons." By Sir JOSEPH J. THOMSON, O.M., D.Sc., F.R.S.

1944. (Oct. 10.) "The Atomic Theory." By Professor A. D. RITCHIE.

JOULE MEMORIAL LECTURES.

1920. (Dec. 14.) "The Work and Discoveries of Joule." By Sir DUGALD CLERK, K.B.E., D.Sc., F.R.S.

1922. (Dec. 5.) "The Rise in Motive Power and the Work of Joule." By Sir CHARLES A. PARSONS, O.M., K.C.B., M.A., D.Sc., F.R.S.

1924. (Mar. 4.) "Thermodynamics in Physiology." By A. V. HILL, O.B.E., M.A., Sc.D., F.R.S.

1928. (Mar. 20.) "Sub-Atomic Energy." By Professor A. S. EDDINGTON, M.A., D.Sc., LL.D., F.R.S.

1930. (Feb. 18.) "Science and Problems of the Times." By A. P. M. FLEMING, C.B.E., M.Sc., M.I.E.E.

1933. (Mar. 14.) "The Psychology of Musical Appreciation." By CHARLES S. MYERS, C.B.E., F.R.S.

1934. (Feb. 27.) "The Expanding Universe as a Thermodynamic System." By Professor E. A. MILNE, M.A., D.Sc., F.R.S.

1936. (Feb. 11.) "The Upper Atmosphere." By Professor E. V. APPLETON, M.A., D.Sc., LL.D., F.R.S.

1938. (Mar. 8.) "The Attainment of Low Temperatures." By Dr. C. G. DARWIN, M.C., M.A., F.R.S.

1940. (Mar. 19.) "New Applications of Physics to Medicine." By Professor JAS. CHADWICK, F.R.S.

1942. (Nov. 10.) "Man and the Weather." By Professor DAVID BRUNT, F.R.S., M.A., Sc.D.

1946. (Feb. 5.) "Atomic Energy." By Professor P. M. S. BLACKETT, F.R.S.

WILDE MEMORIAL LECTURES.

1926. (Mar. 9.) "Brains of Apes and Men." By G. ELLIOT SMITH, M.A., M.D., F.R.S.

1927. (Mar. 22.) "Physiology of Life in the High Andes." By J. BARCROFT, C.B.E., F.R.S.

1929. (Mar. 19.) "The Nature and Origin of Human Speech." By Sir RICHARD PAGET, Bart.

1932. (Mar. 15.) "Man's Place in Nature as shown by Fossils." By Sir ARTHUR SMITH-WOODWARD, LL.D., F.R.S.

1935. (Feb. 12.) "Some Sex Problems in the Fungi." By Professor Dame HELEN GWYNNE VAUGHAN, G.B.E., LL.D., D.Sc., F.L.S.

1937. (Feb. 16.) "Some Problems of the New Stone Age." By HAROLD J. E. PEAKE, M.A., F.S.A.

1939. (Mar. 14.) "Palæolithic Man in the North Midlands." By LESLIE ARMSTRONG, M.C., F.S.I., F.S.A.

1941. (Apr. 29.) "A New Era in Medicinal Treatment." By Sir HENRY H. DALE, President of the Royal Society.

1945. (Mar. 13.) "Some Antibiotics with Special Reference to Penicillin." By Sir HOWARD FLOREY, F.R.S.

1946. (Nov. 18.) "The Tides." By Professor J. PROUDMAN, F.R.S.

CLAYTON MEMORIAL LECTURE.

1947. (Feb. 17.) "Transitions in Thought and Thought in Transition." By Professor H. J. FLEURE, F.R.S.

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.
1900. Sir HENRY E. ROSCOE, F.R.S.
1903. Professor OSBORNE REYNOLDS, LL.D., F.R.S.
1919. Professor Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S.
1931. Sir JOSEPH J. THOMSON, O.M., D.Sc., F.R.S.
1942. Sir LAWRENCE BRAGG, O.B.E., M.C., F.R.S., D.Sc., M.A.

A detailed list of the medals, awarded to John Dalton and others, which are the property of the Society, will be found in Memoirs and Proceedings, Vol. 84, 1939–41, *pp.* xxxi—xxxiii.

A DETAILED LIST OF ARTICLES SALVAGED

FROM 36, GEORGE STREET, MANCHESTER, AFTER THE DESTRUCTION OF THE BUILDING ON DECEMBER 24TH, 1940, WILL BE FOUND IN *Memoirs and Proceedings*, VOL. 84, 1939–41, *pp*. xxxiv—xxxvii.

LIST OF PRESIDENTS OF THE SOCIETY.

Date of Election.	
1781.	PETER MAINWARING, M.D., JAMES MASSEY.
1782–1786.	JAMES MASSEY, THOMAS PERCIVAL, M.D., F.R.S.
1787–1789.	JAMES MASSEY.
1789–1804.	THOMAS PERCIVAL, M.D., F.R.S.
1805–1806.	REV. GEORGE WALKER, F.R.S.
1807–1809.	THOMAS HENRY, F.R.S.
1809.	*JOHN HULL, M.D., F.L.S.
1809–1816.	THOMAS HENRY, F.R.S.
1816–1844.	JOHN DALTON, D.C.L., F.R.S.
1844–1847.	EDWARD HOLME, M.D., F.L.S.
1848–1850.	EATON HODGKINSON, F.R.S., F.G.S.
1851–1854.	JOHN MOORE, F.L.S.
1855–1859.	SIR WILLIAM FAIRBAIRN, Bart., LL.D., F.R.S.
1860–1861.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1862–1863.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1864–1865.	ROBERT ANGUS SMITH, Ph.D., F.R.S.
1866–1867.	EDWARD SCHUNCK, Ph.D., F.R.S.
1868–1869.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1870–1871.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1872–1873.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1874–1875.	EDWARD SCHUNCK, Ph.D., F.R.S.
1876–1877.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1878–1879.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1880–1881.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1882–1883.	SIR HENRY ENFIELD ROSCOE, D.C.L., F.R.S.
1884–1885.	WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.
1886.	ROBERT DUKINFIELD DARBISHIRE, B.A., F.G.S.
1887.	BALFOUR STEWART, LL.D., F.R.S.
1888–1889.	OSBORNE REYNOLDS, LL.D., F.R.S.
1890–1891.	EDWARD SCHUNCK, Ph.D., F.R.S.

* Elected April 28th; resigned office May 5th.

Date of Election.	
1892–1893.	ARTHUR SCHUSTER, Ph.D., F.R.S.
1894–1896.	HENRY WILDE, D.C.L., F.R.S.
1896.	EDWARD SCHUNCK, Ph.D., F.R.S.
1897–1899.	JAMES COSMO MELVILL, M.A., F.L.S.
1899–1901.	HORACE LAMB, M.A., F.R.S.
1901–1903.	CHARLES BAILEY, M.Sc., F.L.S.
1903–1905.	W. BOYD DAWKINS, M.A., D.Sc., F.R.S.
1905–1907.	SIR WILLIAM H. BAILEY, M.I.Mech.E.
1907–1909.	HAROLD BAILY DIXON, M.A., F.R.S.
1909–1911.	FRANCIS JONES, M.Sc., F.R.S.E.
1911–1913.	F. E. WEISS, D.Sc., F.L.S.
1913–1915.	FRANCIS NICHOLSON, F.Z.S.
1915–1917.	SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.
1917–1919.	WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C.
1919.	G. ELLIOT SMITH, M.A., M.D., F.R.S.
1919–1921.	SIR HENRY A. MIERS, M.A., D.Sc., F.R.S.
1921–1923.	T. A. COWARD, M.Sc., F.Z.S., F.E.S.
1923–1925.	H. B. DIXON, C.B.E., M.A., Ph.D., M.Sc., F.R.S., F.C.S.
*1925.	REV. A. L. CORTIE, S.J., D.Sc., F.R.A.S., F.Inst.P.
1925–1927.	H. LEVINSTEIN, D.Sc., M.Sc., F.I.C.
1927–1929.	W. L. BRAGG, O.B.E., M.A., F.R.S.
1929–1931.	C. E. STROMEYER, O.B.E., M.Inst.C.E.
1931–1933.	B. MOUAT JONES, D.S.O., M.A.
1933–1935.	JOHN ALLAN, F.C.S.
1935–1937.	R. W. JAMES, M.A., B.Sc.
1937–1939.	R. H. CLAYTON, M.Sc.
1939–1940.	D. R. HARTREE, M.A., Ph.D., M.Sc., F.R.S.
1940–1944.	H. J. FLEURE, M.A., D.Sc., F.R.S.
1944-1946.	M. POLANYI, Ph.D., M.Sc., M.D., F.R.S.
1946–	T. B. L. WEBSTER, M.A.

LIST OF HONORARY MEMBERS OF THE SOCIETY.

Date of Election.	
Apr. 26th, 1892.	C. LIEBERMANN.
Apr. 17th, 1894.	A. GOUY.
do.	SIDNEY VINES.

* Died May 16th, 1925.

Date of Election.	
Apr. 17th, 1894.	EMIL WARBURG.
Apr. 30th, 1895.	SIR JOSEPH JOHN THOMSON, O.M.
Apr. 24th, 1900.	SIR J. ALFRED EWING.
do.	ANDREW RUSSELL FORSYTH.
do.	ROBERT RIDGEWAY.
May 13th, 1902.	SIR JOSEPH LARMOR.
do.	SIR OLIVER LODGE.
Apr. 28th, 1903.	FRANK WIGGLESWORTH CLARKE.
Apr. 5th, 1910.	WALTHER NERNST.
Nov. 28th, 1922.	NIELS BOHR.
Apr. 13th, 1926.	SAMUEL ALEXANDER, O.M.
do.	ARNOLD SOMMERFELD.
Nov. 16th, 1926.	SIDNEY J. HICKSON.
do.	SIR HENRY A. MIERS.
May 13th, 1930.	F. E. WEISS.

LIST OF CORRESPONDING MEMBERS OF THE SOCIETY.

Date of Election.	
Feb. 3rd, 1920.	W. S. MURPHEY.
Nov. 1st, 1921.	MRS. C. W. PALMER.
Nov. 29th, 1923.	H. F. COWARD.
Apr. 1st, 1924.	G. F. FOWLER.
Dec. 16th, 1924.	G. SENN.
Oct. 13th, 1925.	H. G. A. HICKLING.
Nov. 11th, 1941.	MISS E. OWEN.
Dec. 12th, 1944.	H. J. FLEURE.

THE COUNCIL
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.
FOUNDED 1781.

Elected April 29th, 1947, for the Session 1947–48.

President.

T. B. L. WEBSTER, M.A., F.S.A.

Vice-Presidents.

M. POLANYI, M.D., Ph.D., M.Sc., F.R.S.
MISS A. C. ALEXANDER, B.Sc.
J. KENNER, D.Sc., Ph.D., F.R.S.
N. SMITH, D.Sc., F.C.S.

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MISS D. EMMET, M.A.

Hon. Curator.

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J. COATMAN, C.I.E., M.A.
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J. T. KENDALL, M.A.
MISS E. M. LIND, B.Sc., Ph.D.
M. H. A. NEWMAN, F.R.S.
E. N. MARCHANT, A.R.I.C.
R. N. SPANN, M.A.
T. W. MANSON, M.A., B.Litt., D.D., F.B.A.

Chemical Section.

Chairman: E. N. MARCHANT, A.R.I.C.
Secretary: H. STEVENSON, F.R.I.C.

Social Philosophy Section.

Chairman: J. COATMAN, C.I.E., M.A.
Secretary: B. de COURCY IRELAND, B.A.

LIST OF SOCIETIES AND INSTITUTIONS

TO WHICH THE *Memoirs and Proceedings* ARE SENT.

Societies and Institutions present their publications to the Society's Library with the exception of those marked with a dagger (†).

Aberystwyth. †National Library of Wales.

Abo. Akademie Bibliotek.

Adelaide. Royal Society of South Australia. South Australian Museum. Public Library Museum and Art Gallery of South Australia.

Amsterdam. Koninkliijke Akademie van Wetenschappen. Société Mathématique. Bibliothek van het Wickundig en Genootschap.

Auckland. The Auckland Institute and Museum.

Augsburg. Der naturwissenschaftliche Verein für Schwaben.

Baltimore. Johns Hopkins University.

Bamberg. Naturforschende Gesellschaft.

Bangalore (Madras). Indian Institute of Science.

Basle. Naturforschende Gesellschaft. Naturforsch. Gesellsch. Universitats.-Bibliothek. Helvetica Chimica Acta.

Batavia. Natuurkundige Vereeniging in Nederlandsch-Indië. Bataviaasch Genootschap van Kunsten en Wetenschappen.

Bath. Bath and West and South Counties Society.

Belgrade. Académie Royale Serbe.

Belfast. Naturalists' Field Club.

Bergen. Geofysick Institute.

Berkeley. University of California.

Berlin. Deutsche chemische Gesellschaft. Preussische Geologische Landesanstalt. Preussische Akademie der Wissenschaften. Gesellschaft der Naturforschender Freunde.

Besançon. Société d'émulation de Doubs.

Birmingham. Natural History and Philosophical Society.

Bloemfontein. National Museum.
Bologna. Reale Accademia delle Scienze dell'Istituto.
Bombay. Branch of the Royal Asiatic Society of Bengal.
Bonn. Naturhistorischer Verein der preussischen Rheinlande und Westfalens.
Bordeaux. Société des Sciences physiques et naturelles.
Boston. American Academy of Arts and Sciences.
Boulder. University of Colorado.
Bremen. Naturwissenschaftlicher Verein.
Brisbane. Royal Geographical Society of Australasia. Queensland Museum. Royal Society of Queensland.
Bristol. Naturalists' Society.
Brno. Faculty of Science, Masaryk University.
Brooklyn (N.Y.). Institute of Arts and Sciences.
Brussels. Académie Royale de Belgique. Musée Royal d'Histoire Naturelle de Belgique. Société Belge de Géologie Paléontologie et Hydrologie.
Buckhurst Hill. Essex Field Club.
Buenos Aires. Sociedad Cientifica Argentina.
Buffalo. Society of Natural Sciences.

Caen. Académie nationale des Sciences, Arts et Belles-Lettres. †Société Linnéenne de Normandie.
Calcutta. Agricultural Research Institute (Pusa). Geological Survey of India. Indian Association for the Cultivation of Science. Meteorological Department of India (Poona). Royal Asiatic Society of Bengal.
Cambridge. Philosophical Society. †University Library.
Cambridge (Mass.) Harvard College. †Massachusetts Institute of Technology Library.
Canberra. National Library.
Cape Town. Royal Society of South Africa. South African Museum.
Cardiff. Naturalists' Society.
Catania. Accademia Gioenia di Scienze naturali.
Chambéry. Académie des Sciences. Belles-Lettres et Arts de Savoie.
Changsa. Geological Survey of China.
Chapel Hill. Elisha Mitchell Scientific Society.

Charlottenburg. Physikalischer-Technischer Reichsanstalt.

Cherbourg. Société nationale des Sciences naturelles.

Chicago. Astrophysical Journal. Field Museum of Natural History. University of Chicago Library.

Cincinnati. Lloyd Library and Museum. †American Association for the Advancement of Science. Society of Natural History.

Clermont-Ferrand. La Société des amis de l'Université de Clermont.

Colorado Springs. Colorado College Coburn Library.

Columbia. University of Missouri.

Columbus. Ohio Journal of Science. Ohio State University.

Copenhagen. Kongeligt Danske Videnskabernes Selskab. Kongeligt Nordisk Oldskrift-Selskab. Naturhistorisk Förening.

Cracow. Société Polonaise Mathématique.

Cullercoats. See Newcastle-upon-Tyne.

Danzig. Naturforschende Gesellschaft. Westpreussischer Botanisch-Zoologischer Verein.

Davenport. Academy of Natural Sciences.

Delft. Technische Hoogeschool.

Dijon. Académie des Sciences, Arts et Belles-Lettres.

Dorpat. Naturforschende Gesellschaft. Universitas Tartuensis.

Douai. Société d'Agriculture, Sciences et Arts du Département du Nord.

Draguignan. Société d'études scientifiques et archéologiques.

Dublin. †National Library of Ireland. Royal Dublin Society. Royal Irish Academy. †Trinity College Library.

Dunkerque. Société Dunkerquoise pour l'encouragement des Sciences.

Durban. †Corporation Museum.

Edinburgh. Botanical Society. Geological Society. Mathematical Society. †National Library of Scotland. Royal Botanic Gardens. Royal Observatory. Royal Physical Society. Royal Society. Royal Scottish Society of Arts. †Scottish Meteorological Society. University Library.

Elberfeld. Naturwissenschaftlicher Verein.

Epinal. Société d'émulation des départements des Vosges.

Erlangen. Physikalisch-medizinische Societät.

Evreux. Société libre d'Agriculture, Sciences, Arts et Belles-Lettres de d'Eure.

Falmouth. Royal Cornwall Polytechnic Society.

Florence (Firenze). Biblioteca Nazionale Centrale.

Frankfurt-am-Main. Physikalischer Verein. Senckenbergische Naturforschende Gesellschaft.

Freiburg i. Br. Naturforschende Gesellschaft.

Geneva. Institut national Génévois. Société de Physique et d'Histoire Naturelle. See also Basle.

Genova. Museo Civico di Storia Naturale.

Giessen. Oberhessische Gesellschaft für Natur-und Heilkunde.

Glasgow. Geological Society. Glasgow and Andersonian Natural History and Microscopical Society. Royal Philosophical Society. †University Library.

Görlitz. Naturforschende Gesellschaft.

Göteborg. Göteborgs Stadtsbibliotek (Högskole).

Göttingen. Gesellschaft der Wissenschaften.

Grahamstown. Albany Museum.

Granville. Denison University.

Graz. Verein des Aertze in Steiermark.

Greenwich. Royal Observatory.

Haarlem. Hollandsche Maatschappig der Wetenschappen. Musée Teyler. Nederlandsche Maatschappig ter bevordering van Nijverheid. Geologisch Bureau van het Nederlandsch Mijngebied.

Halifax, N.S. Nova Scotian Institute of Science.

Halle. Akademie der Naturforscher. Naturforschende Gesellschaft und naturwissenschaftlicher Verein.

Hamburg. Naturwissenschaftlicher Verein. Mathematische Gesellschaft.

Hanley. See Stoke-on-Trent.

Hanover. Naturhistorische Gesellschaft.

Hartford (Conn.). Connecticut State Library (Geological and Natural History Survey).

Heidelberg. Badische Sternwarte. Naturhistorischmedizinischer Verein.

Helsingfors. Finska Vetenskaps Societeten. Societas pro Fauna et Flora Fennica.

Hermannstadt. Siebenbürgischer Verein für Naturwissenschaften.

Hobart. Royal Society of Tasmania.

Hong Kong. Royal Observatory.

Hull. †Scientific and Field Naturalists' Club. †Yorkshire Naturalists' Union.

Indianapolis. Department of Geology and Natural Resources of Indiana.

Iowa City. Iowa State University. Iowa Geological Survey.

Ithaca. Cornell University. Agricultural Experimental Station.

Johannesburg. South African Association for the Advancement of Science.

Kazan. Imperial University. Society of Archæology.

Kel. Naturwissenschaftlicher Verein für Schleswig-Holstein. Institut für Meereskunde der Universität Kiel.

Kiev. Academy of Sciences of the Ukrainian Soviet Socialistic Republic. The Academy Institute for Physical Chemistry.

Kodaikanal. See Madras.

Königsberg i. Pr. Universitäts-Sternwarte. Physikalisch-ökonomische Gesellschaft.

Kyoto. College of Science and Engineering, Imperial University.

Lausanne. Société Vaudoise des Sciences Naturelles.

Lawrence. Kansas University.

Leeds. Geological Association. Philosophical and Literary Society. Yorkshire Geological Society.

Leeuwarden. Friesch Genootschap, van Geschied-, Oudheid -en Taalkunde.

Leicester. Literary and Philosophical Society.

Leiden. Maatschappig der Nederlandsch Letterkunde. Rijks Geologisch—Mineralogisch Museum. Rijks Herbarium. Société Néerlandaises de Zoologie.

Leipzig. Naturforschende Gesellschaft. Jablonowskische Gesellschaft. Sächsische Gesellschaft der Wissenschaften.

Le Mans. Société d'Agriculture, Sciences et Arts de la Sarthe.

Lemberg. Bibliothek der Sevcenk Gesellschaft.

Leningrad. Academy of Sciences of the Union of Socialist Soviet Republics.

Liége. Société Géologique de Belgique. Société Royale des Sciences.

Lille. Société des Sciences d'Agriculture et des Arts. L'Universitaire.

Lima, Peru. Cuerpo de Inginieros de Minas del Peru.

Lincoln, U.S.A. Nebraska Geological Survey. University of Nebraska.

Lisbon. Observatorio Central Meteorologico. Observacões meteorologicas da Madeira.

Liverpool. Biological Society. Engineering Society. Geological Society. Hartley Botanical Laboratories. Literary and Philosophical Society.

London. British Association. British Museum (Natural History). British Museum (Library of Pure and Applied Science). British Museum Copyright Office. Chemical Society. Faraday Society. Geological Society. Institution of Civil Engineers. Institution of Electrical Engineers. Institution of Mechanical Engineers. Linnean Society. Mathematical Society. Meteorological Office. National Central Library. Patent Office. Physical Society. Quekett Microscopical Society. Royal Society. Royal Astronomical Society. Royal Geographical Society. Royal Horticultural Society. Royal Institute of British Architects. Royal Institution of Great Britain. Royal Meteorological Society. Royal Observatory. Royal Society of Arts. †Subject Index to Periodicals. University Library. Zoological Society.

Lucca. Reale Accademia Lucchese di Scienze, Lettere, ed Arti.

Lund. The University Library.

Luxembourg. Institut Grand Ducal de Luxembourg.

Lwow. See Lemberg.

Lyon. Académie des Sciences. L'Université.

Madison. Wisconsin Academy of Sciences, Arts and Letters, Wisconsin Geological and Natural History Survey.

Madras. Observatory (Kodaikanal). University.

Madrid. Academia de Ciencias. Sociedad Matemática Española.

Manchester. Association of Engineers. †Chetham's Library. †Christie Library. Conchological Society. Geographical Society. Geological Association. Microscopical Society. †Municipal College of Technology. †Central Library. Shirley Institute. Statistical Society. Textile Institute.

Manhattan. Library of Kansas State College of Agriculture and Applied Science.

Manila. Bureau of Science. Ethnological Survey.

Marburg. Gesellschaft zur Beförderung der gesammten Naturwissenschaften.

Marseilles. Faculté des Sciences de l'Université.

Melbourne. Royal Society of Victoria.

Metz. Académie de Metz.

Mexico. Instituto Geológico. Academia Nacional de Ciencias. "Antonio Alzate."

Middleburg. Zeeuwsch Genootschap der Wetenschappen.

Milan. Reale Istituto Lombardo di Scienze e Lettere. Reale Osservatorio di Brera in Milano (Merati, Como.). Società Italiana di Scienze Naturali, e Museo Civico.

Minneapolis. University of Minnesota. †Academy of Natural Sciences.

Missoula. University of Montana.

Modena. Regia Accademia di Scienze, Lettere ed Arti.

Montevideo. Museo de Historia Natural.

Montpellier. Académie des Sciences et Lettres.

Moscow. Société des Naturalistes de Moscou.

Munich. Bayerische Akademie der Wissenschaften.

Nancy. Société des Sciences de Nancy.

Naples. Accademia delle Scienze fisiche e matematiche. Accademia di Archeologia, Lettere e Belle Arti. Società Reale di Scienze.

Neuchâtel. Société neuchâteloise des Sciences naturelles.

Newcastle-upon-Tyne. Dove Marine Laboratories, Cullercoats. †Literary and Philosophical Society. Natural History Society of Northumberland, Durham, and Newcastle-upon-Tyne. University of Durham Philosophical Society.

New Haven (Conn.). Connecticut Academy of Arts and Sciences. Bingham Oceanographic Collection.

New York. Academy of Sciences. American Chemical Society. American Mathematical Society. American Museum of Natural History. Meteorological Observatory (Central Park). The Vanderbilt Marine Museum.

Nîmes. Académie de Nîmes.

Norman. Oklahoma Academy of Science.

Norwich. Norfolk and Norwich Naturalists' Society.

Offenbach. Der Offenbacher Verein für Naturkunde.

Oporto. Academica Polytechnica Porto.

Oslo. Norske Videnskaps Akademie. Norsk Meteorologisk Institut. Observatorium. Bibliothèque de l'Université Royale de Norvège.

Ottawa. Dominion Astrophysical Observatory. Geological Survey of Canada. Royal Society of Canada.

Oxford. †Bodleian Library. Radcliffe Library.

Palermo. Reale Accademia di Scienze, Lettere, e Belle Arti.

Paris. Académie des Sciences. École nationale supérieure des Mines. École polytechnique. Muséum d'Histoire naturelle.

Peiping. Geological Society of China.

Philadelphia. Academy of Natural Sciences. American Philosophical Society. Franklin Institute. †Philadelphia Commercial Museum. Wagner Free Institute of Science.

Pietermaritzburg. †Government Geologist, Surveyor General's Office. Natal Government Museum.

La Plata. Direccion General de Estadistica de la Prov. Buenos Aires. Universidad Nacional, Facultad de Ciencias Fisico-Matematicas.

Plymouth. Plymouth Institution and Devon and Cornwall Natural History Society.

Poona. (See Calcutta.)

Portici. Laboratorio di Zoologia generale e agraria, R. Scuola sup. di Agricoltura.

Prague. Böhmische Gesellschaft der Wissenschaft.

Pretoria. The University.

Puget Sound. See Seattle.

Pusa. See Calcutta.

Rennes. Société Scientifique de Bretagne.

Rheims. Académie nationale.

Riga. Naturforscher Verein.

La Rochelle. Société des Sciences naturelles de la Charente inférieure.

Rochdale. Literary and Scientific Society.

Rochester, N.Y. Academy of Science.

Rock Island. Augustana College Library.

Rome. Institut International d'Agriculture. Reale Accademia dei Lincei. Società Italiana per il progresso delle Scienze. Vatican Observatory (Specola Vaticana).

Rostock. Verein der Freunde der Naturgeschichte in Mecklenburg.

Rouen. Académie des Sciences.

Sacramento. See Berkeley.

St. Louis. Missouri Botanical Garden. †Academy of Science. The Washington University.

St. Paul. See Minneapolis.

Salford. †Royal Museum and Library.

San Diego. Society of Natural History.

San Francisco. California Academy of Sciences.

Santiago. Deutscher wissenschaftlicher Verein.

Sassari. Regia Università Istituto Fisiologico.

Seattle. University of Washington. Oceanographical Laboratories. Puget Sound Marine Biological Station.

Sendai. Tohoku Imperial University.

Sheffield. Midland Institute of Mining, Civil and Mechanical Engineers. Safety in Mines Research Board Laboratories.

Shrewsbury. Caradoc and Severn Valley Field Club.

Simla. See Calcutta.

Southport. Fernley Observatory.

Stockholm. Entomologiska Föreningen. Kongeliga Svenska Vetenskaps-Akademi. Royal Library. Sveriges Geologiska Undersökning. Stockholms Högkolas Bibliotek.

Stoke-upon-Trent. North Staffordshire Field Club.

Stratford. The Essex Field Club.

Swansea. Scientific and Field Naturalists' Society.

Sydney. Australian Museum. Linnean Society of New South Wales. Royal Society of New South Wales.

Tashkent. L'Université de l'Asie Centrale.

Taihoku. Imperial University.

Tartu. See Dorpat.

Teddington. National Physical Laboratory.

Tiflis. Geophysikalisches Observatorium Georgiens.

Tokyo. Faculty of Science, Imperial University of Tokyo. Imperial Academy. Institute of Electrical Engineers of Japan. Institute of Physical and Chemical Research. Physico-Mathematical Society of Japan. National Research Council of Japan.

Toronto. University Library.

Toulouse. Académie des Sciences, Inscriptions, et Belles-Lettres.

Trondhjem. Kongelige Norske Videnskabers Selskab Museet

Troyes. Société Académique d'Agriculture de l'Aube.

Tufts, Massachusetts. Tufts College.

Uccle. L'Observatoire royale et l'Institut royal Météorologique de Belgique.

Ukraine. (See Kiev.)

Upsala. Kongeliga Universitet. Kongeliga Vetenskaps-Societeten.

Urbana. Illinois State Geological Survey. Illinois State Laboratory of Natural History. University of Illinois.

Utrecht. Koninklijk Nederlandsch Meteorologisch Instituut. Provincial Utrechtsch Genootschap van Kunsten en Wetenschappen.

Venice. Reale Istituto Veneto di Scienze, Lettere, ed Arti.
Victoria, B.C. Dominion Astrophysical Observatory.
Vienna. Akademie der Wissenschaften. Universitäts-Sternwarte. Naturhistorisches Museum. Zoologisch-Botanische Gesellschaft. Oesterreichische Gesellschaft für Meteorologie.

Washington University. See St. Louis, Mo.
Washington, University of. See Seattle.
Washington, D.C. Bureau of Standards, Dept. of Commerce and Labor. Carnegie Institute. Smithsonian Institution, Bureau of Ethnology. Smithsonian Institution, United States National Museum. U.S. Coast and Geodetic Survey. U.S. Department of Agriculture. U.S. Geological Survey. U.S. Naval Observatory. †U.S. Patent Office.
Watford. Hertfordshire Natural History Society and Field Club.
Wellington, N.Z. Royal Society of New Zealand.
Wiesbaden. Nassauischer Verein für Naturkunde.
Wurzburg. Physikalisch-medizinische Gesellschaft.

York. Yorkshire Philosophical Society.

Zürich. Naturforschende Gesellschaft. Schweizerischer Meteorologische Central-Anstalt.

LIST OF ORDINARY MEMBERS OF THE SOCIETY, MAY, 1948.

Year of Election.

1928. Eric Ahlquist, The Croft, Ladybrook Road, Bramhall Park, Cheadle Hulme, Cheshire.

1920. Miss A. C. Alexander, B.Sc., c/o Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1946. Rev. Ronald Allan, The Holt House, Mobberley, Cheshire.

1942. Dr. Alexander Altmann, 38, Waterpark Road, Salford, 7.

1946. F. H. Angold, 470, Moss Lane East, Manchester, 14.

1928. G. E. Archer, M.B., Ch.B., D.L.O., F.R.C.S.(Ed.), West Thorpe, Park Road, Bowdon, Cheshire.

1945. Godfrey Armitage, 3, Didsbury Park, Manchester, 20.

1945. Mrs. G. Armitage, 3, Didsbury Park, Manchester, 20.

1943. A. Leslie Armstrong, M.C., M.Sc., F.S.I., F.S.A., 27, Victoria Road, Stockton Heath, Warrington.

1926. J. R. Ashworth, D.Sc., 55, King Street South, Rochdale.

1946. Miss E. E. Backhouse, 32, Panton Street, Cambridge.

1920. F. W. Bailey, Haven House, Broadbottom, Cheshire.

1940. Mrs. E. A. Bardsley, Alexander House, 7, Queens Road, Oldham.

1945. Lady Barlow, Dene House, Lancaster Road, Didsbury, Manchester, 20.

1948. P. H. Barnes, 128, Burlington Street, Ashton-under-Lyne, Lancs.

1947. M. S. Bartlett, Department of Mathematics, The University, Manchester, 13.

1919. W. H. Bentley, D.Sc., F.C.S., 7, Grosvenor Road, Claughton, Birkenhead, Cheshire.

1947. A. H. Birch, 47, Grafton Street, Manchester, 13.

1948. Miss M. McLeod Black, M.A., 1, Belmore Avenue, Higher Crumpsall, Manchester, 8.

Year of Election.

1937. Professor P. M. S. Blackett, M.A., F.R.S., The University, Manchester, 13.

1945. John Boardman, B.Com. (Lond.), 11, Parkfield Road, Cheadle Hulme, Cheshire.

1945. W. R. Boon, B.Sc., Ph.D., F.R.I.C., 15, Gorsey Road, Wilmslow, Cheshire.

1914. Frank Bowman, M.A., M.Sc.Tech., 12, Clifton Avenue, Fallowfield, Manchester, 14.

1947. Professor A. M. Boyd, 64, Platt Lane, Manchester, 14.

1914. Major A. W. Boyd, M.C., M.A., F.R.E.S., Frandley House, Nr. Northwich, Cheshire.

1945. Miss Bozman, Manchester High School for Girls, 121, Barlow Moor Road, Manchester, 20.

1927. J. Crighton Bramwell, M.A., M.D., F.R.C.P., 15, Lorne Street, Manchester, 13.

1945. Ronald Brightman, M.Sc., A.C.G.F.C., F.R.I.C., 19, Danesway, Prestwich, Nr. Manchester.

1936. W. H. Brindley, M.C., M.A., M.Sc., Ph.D., 11, Pikes Lane, Glossop, Derbyshire.

1947. P. M. Bromley, B.A., 31, Ashfield Road, Sale, Cheshire.

1934. Ernest Brunner, Ph.D., Oak Tree Cottage, Castle Hill, Prestbury.

1929. H. E. Buckley, D.Sc., Bradda, Hazelhurst Road, Worsley, Lancs.

1945. R. F. I. Bunn, 147, Old Hall Lane, Rusholme, Manchester, 14.

1945. Miss Mabel Burdess, Edge Hill Training College, Ormskirk, Lancs.

1925. G. N. Burkhardt, M.Sc., Ph.D., F.I.C., The University, Manchester, 13.

1941. Miss A. Burton, Slethos House, 68, Sackville Street, Manchester, 1.

1920. Miss Marion Chadwick, M.Sc.Tech., 1, Didsbury Road, Stockport.

1899. D. L. Chapman, M.A., F.R.S., Jesus College, Oxford.

1943. Professor H. B. Charlton, The University, Manchester, 13.

Year of Election.

1946. Professor C. R. Cheney, 21, Rathen Road, Withington, Manchester, 20.

1943. S. E. Chiotides, 29, Minshull Street, Manchester, 1.

1946. F. Chorley, M.Sc., A.R.I.C., 32, St. Michaels Avenue, Bramhall, Cheshire.

1929. J. D. Chorlton, M.Sc., 62, Palatine Road, Withington, Manchester, 20.

1939. G. F. Clayton, 1, Parkfield Road, Didsbury, Manchester, 20.

1929. J. H. Clayton, Lymm Hall, Lymm, Cheshire.

1941. John Coatman, C.I.E., M.A., c/o The Firs, Fallowfield, Manchester, 14.

1945. Mrs. John Coatman, c/o The Firs, Fallowfield, Manchester, 14.

1945. W. Mansfield Cooper, The University, Manchester, 13.

1924. C. G. Core, M.Sc., Greystoke, Palatine Road, Manchester, 20.

1947. R. J. Cornish, M.Sc., College of Technology, Manchester, 1.

1934. Miss R. E. S. Cox, The Bungalow, Park Road, Monton, Eccles.

1916. Mrs. M. B. Craven (Life Member), M.Sc.Tech., The College of Technology, Manchester, 1.

1943. H. S. Critchley, "Three Gates," Higher Disley, Cheshire.

1945. Dr. C. J. T. Cronshaw, "Alnwick," Prestwich Park, Prestwich, Nr. Manchester.

1919. Miss Mary Cunningham, D.Sc., 27, Clarence Terrace, Bollington, Nr. Macclesfield.

1923. George W. Cussons, The Technical Works, Lower Broughton, Salford, 7.

1929. J. A. Darbyshire, M.Sc., "Melandra," Kershaw Road, Failsworth, Manchester.

1945. D. G. Davey, M.Sc., Ph.D., F.Z.S., Rose Lodge, Bury New Road, Prestwich, Nr. Manchester.

1946. E. Devons, 1, Darley Avenue, Manchester, 20.

Year of Election.

1918. Miss Annie Dixon, M.Sc., F.R.M.S. (Life Member), Kauguri, Batchford Drive, St. Albans.

1947. Professor S. Dobrin, The University, Manchester, 13.

1945. Professor Dorothy Emmet, M.A., 21, Yew Tree Lane, Northenden, Manchester.

1945. Dr. A. G. Evans, Chemistry Department, The University, Manchester, 13.

1946. B. S. E. Farrow, Esq., 82, Woodford Road, Bramhall, Cheshire.

1942. W. R. Fielding, M.A., M.Sc., M.Ed., Manor House, Manor Road, Fleetwood.

1924. Sir A. P. M. Fleming, C.B.E., Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

1932. Professor H. J. Fleure, M.A., D.Sc., F.R.S., 275, Church Road, London, S.E.19.

1940. R. P. Foulds, M.Sc., F.I.C., F.T.I., c/o Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1947. Wright Garside, Brereton, Ogden Road, Bramhall, Cheshire.

1922. P. Gaunt, F.R.I.C., Ladybarn, Letchworth, Herts.

1922. A. Gill, B.Sc., A.I.C., Hardwick, 30, Woodhill Drive, Prestwich, Nr. Manchester.

1947. Professor S. Goldstein, The University, Manchester, 13.

1947. A. H. Goulty, M.A., 7, Didsbury Park, Manchester, 20.

1947. Mrs. A. H. Goulty, 7, Didsbury Park, Manchester, 20.

1926. W. Howard Goulty (Life Member), Cornbrook, Mortimer Common, Berkshire.

1947. Herbert Gudgeon, 16, Ash Walk, Alkrington, Middleton, Lancs.

1946. W. Hagenbuch, The University, Manchester, 13.

1945. A. J. Hailwood, B.Sc., 3, Hazel Road, Altrincham.

1946. H. Hartley, 84, Macclesfield Road, Buxton, Derbyshire.

1929. Professor D. R. Hartree, M.A., Ph.D., F.R.S. (Life Member), 13, Barrow Road, Cambridge.

Year of Election.

1943. Miss M. V. Malcolm-Hayes, Mayfield, The Hough, Wilmslow, Cheshire.

1924. H. Hayhurst, F.R.I.C., A.M.I.Chem.E., F.R.E.S. (Life Member), Fouray, Parkfield Road, Didsbury, Manchester, 20.

1924. Mrs. H. Hayhurst, M.Sc. (Life Member), Fouray, Parkfield Road, Didsbury, Manchester, 20.

1919. D. M. Henshaw, c/o Messrs. W. C. Holmes & Co. Ltd., Engineers, Huddersfield.

1946. H. Hepworth, D.Sc., F.R.I.C., Ridgeway, Hill Top, Wilmslow, Cheshire.

1928. J. B. M. Herbert, M.Sc., The University, Manchester, 13.

1942. Professor D. H. Hey, King's College, Strand, London, W.C.2.

1943. Alan Howard Hilton, L.D.S., 135, Great Clowes Street, Salford, 7.

1948. W. D. Hincks, Department of Entomology, Manchester Museum, The University, Manchester, 13.

1944. Samuel Hird, O.B.E., M.Sc., 12, Oaklands Avenue, Stockport.

1946. Professor E. L. Hirst, F.R.S., The University, Manchester, 13.

1936. K. G. Holden, B.A., "Downshot," Alderley Edge, Cheshire.

1936. N. N. Holden, Northlea, Altrincham, Cheshire.

1943. Ernest Hollings, Dunleath, 17, Alexandra Road, Sale, Cheshire.

1944. Rev. R. V. Holt, Unitarian College, Victoria Park, Manchester, 14.

1947. J. A. Hornby, B.A., 687, Blackburn Road, Bolton.

1920. T. Horner, M.Sc.Tech., A.I.C. (Life Member), Bronwylfa, Plasuchaf Avenue, Prestatyn, North Wales.

1926. O. R. Howell, B.Sc., Ph.D., Spey Lodge, 29, Palatine Road, Withington, Manchester, 20.

Year of Election.

1945. N. S. Hubbard, Broughton Copper Works, P.O. Box 346, Manchester.

1919. Henry Humphreys, 101, Frederick Street, Oldham.

1945. B. de Courcy Ireland, B.A., 22, Alan Road, Withington, Manchester, 20.

1945. Dr. E. J. F. James, M.A., D.Phil., The Grammar School, Manchester, 14.

1945. Mrs. E. J. F. James, 143, Old Hall Lane, Fallowfield, Manchester, 14.

1923. R. W. James, B.Sc., The University, Cape Town, South Africa.

1943. Professor Geoffrey Jefferson, High Bank, Stenner Lane, Didsbury, Manchester, 20.

1943. Mrs. Jefferson, High Bank, Stenner Lane, Didsbury, Manchester, 20.

1945. Professor J. Jewkes, The University, Manchester, 14.

1924. Francis Jones, F.R.I.B.A., 178, Oxford Road, Manchester, 13.

1923. P. Guthlac Jones, Malista, Limefield Road, Kersal, Manchester, 7.

1945. J. T. Kendall, M.A., Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

1928. Professor J. Kenner, D.Sc., Ph.D., F.R.S., The College of Technology, Manchester, 1.

1940. C. M. Keyworth, M.Sc., F.I.C., A.M.I.Chem.E., "Prenton," Buxton Road, Leek, Staffs.

1931. H. S. Land, 24, Hillington Road, Ashton-on-Mersey, Cheshire.

1946. Professor R. E. Lane, 6, Linden Road, Didsbury, Manchester, 20.

1909. Professor W. H. Lang, M.B., C.M., D.Sc., M.Sc., F.R.S., 2, Heaton Road, Withington, Manchester, 20.

1917. Sir Kenneth Lee, LL.D., Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1940. H. R. Leech, The Lindens, Balmoral Road, Grappenhall, Nr. Warrington.

Year of Election.

1943. Miss Myee Dorothy Leigh, M.A., Lyncroft, Higher Ainsworth Road, Radcliffe, Manchester.

1931. Miss C. M. Legge, M.A., A.R.C.A., c/o Association for Moral and Social Hygiene, Livingstone House, Broadway, Westminster, London, S.W.1.

1943. Miss Margaret Lever, Lyncroft, Higher Ainsworth Road, Radcliffe.

1948. Professor W. A. Lewis, Department of Economics, The University, Manchester, 13.

1944. Dr. E. M. Lind, B.Sc., Ph.D., Ashburne Hall, Fallowfield, Manchester, 14.

1928. H. Lowery, D.Sc., Ph.D., M.Ed., F.Inst.P., F.C.P., Principal, South-West Essex Technical College, Forest Road, London, E.17.

1947. Thomas Maguire, 10, Great Cheetham Street West, Salford, 7.

1941. Rev. H. McLachlan, M.A., D.D., 11, Sydenham Avenue, Liverpool, 17.

1946. Miss A. MacLennan, 30, Errwood Road, Levenshulme, Manchester, 19.

1945. Mrs. McManus, *Manchester Guardian*, Cross Street, Manchester, 2.

1943. Miss C. E. MacWhirter, 33, Burlington Road, Withington, Manchester, 20.

1945. Professor T. W. Manson, M.A., B.Litt., D.D., F.B.A., Woodheys, Mersey Road, Heaton Mersey, Stockport, Cheshire.

1931. E. N. Marchant, A.R.I.C., Whetherstones, Wilbraham Road, Chorlton-cum-Hardy, Manchester, 21.

1945. C. H. Marsh, Henry Simon Ltd., Cheadle, Cheshire.

1941. Dr. A. R. Martin, 30, Styal Road, Wilmslow, Cheshire.

1929. H. G. Mather, Sunnymead, Hamilton Road, Whitefield.

1945. R. R. Melhuish, B.Sc., Ph.D., 10, Hill Top Avenue, Prestwich.

1939. Mrs. A. D. Melland, 17, Ladybarn Road, Fallowfield, Manchester, 14.

Year of Election.

1939. C. H. Melland, M.D., 17, Ladybarn Road, Fallowfield, Manchester, 14.

1927. W. Melland, M.A., J.P., 1b, Cooper Street, Manchester, 2.

1936. Professor John Morley, Ch.M., F.R.C.S., The Elms, Wilmslow Road, Didsbury, Manchester, 20.

1912. J. E. Myers, O.B.E., D.Sc., The College of Technology, Manchester, 1.

1945. Professor M. H. A. Newman, F.R.S., The University, Manchester, 13.

1927. J. M. Nuttall, D.Sc., The University, Manchester, 13.

1945. Professor R. A. C. Oliver, The University, Manchester, 13.

1936. T. H. Oliver, M.D., Northern Assurance Buildings, Albert Square, Manchester, 1.

1948. J. M. Owen, Manox House, Canal Street, Miles Platting, Manchester, 10.

1946. C. Paine, B.Sc., Ellesmere, Macclesfield Road, Wilmslow, Cheshire.

1947. Ronald Peacock, M.A., Ph.D., The University, Manchester, 13.

1942. David Pearson, B.A., 22, Dryden Avenue, Cheadle, Cheshire.

1946. N. G. C. Pearson, M.B.E., M.A., 1, Dickinson Street West, Manchester, 2.

1946. Miss D. Pilkington, Firwood, Alderley Edge, Cheshire.

1946. Sir Harry Platt, 11, Lorne Street, Manchester, 13.

1946. P. H. Plesch, A.R.I.C., M.A., Department of Chemistry, The University, Manchester, 13.

1934. Professor M. Polanyi, M.D., Ph.D., M.Sc., F.R.S., 10, Gilbert Road, Hale, Cheshire.

1945. Mrs. M. Polanyi, 10, Gilbert Road, Hale, Cheshire.

1945. F. R. Poskitt, Esq., Bolton School, Bolton, Lancs.

1931. Professor W. J. Pugh, O.B.E., B.A., D.Sc., F.G.S., Rathen House, Spath Road, Didsbury, Manchester, 20.

Year of Election.

1931. A. McLean Ranft, 1, Framingham Road, Brooklands, Cheshire.

1923. Professor H. S. Raper, C.B.E., D.Sc., M.B., Ch.B., M.Sc., F.R.S., The University, Manchester, 13.

1945. William Rawlinson, Nethersyde, Wilmslow, Cheshire.

1929. Dr. W. J. Sutherland Reid, 10, St. John Street, Manchester.

1946. Miss Penelope Renold, Woodheys, Mersey Road, Heaton Mersey, Stockport.

1946. R. J. W. Reynolds, B.Sc., Ph.D., A.R.I.C., 13, Brierley Drive, Alkrington, Middleton, Lancs.

1920. Professor A. D. Ritchie, M.A. (Life Member), The University, Manchester, 13.

1947. F. C. Robinson, Holmdale, Hargate Drive, Hale, Cheshire.

1909. Miss Rona Robinson, M.Sc., F.I.C., Mosley Villa, Mitford Road, Fallowfield, Manchester, 14.

1947. Brian Rodgers, Department of Economics, The University, Manchester, 13.

1946. J. G. Roger, B.Sc., F.I.S., Manchester Museum, The University, Manchester, 13.

1947. J. D. Rose, B.A., B.Sc., 12, Orford Road, Prestwich.

1948. Professor Rosenfeld, 215, Old Hall Lane, Fallowfield, Manchester, 14.

1947. Richard Rowe, Ph.D., A.R.I.C., Woodroyd, Oldfield Road, Altrincham, Cheshire.

1920. W. A. Silvester, M.Sc. (Life Member), 4, Claremont Road, Cheadle Hulme, Cheshire.

1941. A. P. Simon, Lyndale, West Didsbury, Manchester, 20.

1906. Norman Smith, D.Sc., F.C.S., 22, Broadway, Withington, Manchester, 20.

1946. R. N. Spann, M.A., 17, Brooklyn Crescent, Cheadle, Cheshire.

1926. Wm. Speight, M.Sc., The Grammar School, Manchester, 13.

Year of Election.

1911. Miss Laura E. Start, M.Ed., Three Oaks, Mosley Road, Exmouth, Devon.

1921. H. Stevenson, F.R.I.C., 31, Barchester Road, Cheadle, Cheshire.

1936. Sir John S. B. Stopford, M.D., Sc.D., F.R.S., The University, Manchester, 13.

1936. J. F. Straatman, 208, Heywood Road, Prestwich, Nr. Manchester.

1924. Stephen H. Straw, D.Sc., The University, Manchester, 13.

1924. G. A. Sutherland, M.A., Dalton Hall, Victoria Park, Manchester, 14.

1938. H. Frankland Taylor (Life Member), Innisfree, Lynne Road, Disley, Cheshire.

1945. Sir John Taylor, 12, Exchange Street, Manchester, 2.

1945. Dr. A. E. Teale, The University, Manchester, 13.

1919. F. H. Terleski, Oakwood, Hilton Lane, Prestwich. Manchester.

1921. Professor F. C. Thompson, B.Sc., M.Sc., D.Met., The University, Manchester, 13.

1942. H. T. Thorp, " Beechwood," Pinfold Lane, Whitefield, Manchester.

1931. F. C. Toy, D.Sc., Tregays, Fletsand Road, Wilmslow, Cheshire.

1945. Lawrence Tremlett, The College of Technology, Manchester, 1.

1936. Miss H. L. Tuer, 8, The Garth, Yarnton, Oxford.

1931. H. A. Turner, M.Sc., A.I.C. (Life Member), Ministry of Supply, Chemical Defence, Research Station, Porton, Wilts.

1947. P. F. R. Venables, Ph.D., B.Sc., F.R.I.C., Royal Technical College, Peel Park, Salford, 5.

1944. Miss Emily Verity, B.Sc., 19, Wellington Road, Fallowfield, Manchester, 14.

1921. H. Walkden (Life Member), The Raft, Derbyshire Road, Sale, Cheshire.

Year of Election.

1944. R. S. Waller, M.B.E., M.A., Extra-Mural Department, The University, Manchester, 13.

1946. Professor C. W. Wardlaw, The University, Manchester, 13.

1936. Professor T. B. L. Webster, M.A. (Life Member), The University, Manchester, 13.

1945. Mrs. T. B. L. Webster, 4, Rusholme Gardens, Rusholme, Manchester.

1942. Professor F. E. Weiss, 73, Longton Avenue, Sydenham, London, S.E.26.

1947. Miss L. A. Whale, Pendleton High School for Girls, Salford.

1943. Frank W. Whaley, M.Sc., 126, Shaw Heath, Stockport.

1919. A. F. Williams, Bournebridge, Meshaw, South Molton, Devon.

1947. D. F. Williams, 8, St. Ann's Square, Heald Green, Cheadle, Cheshire.

1946. D. G. M. Williams, 8, Lansdowne House, Wilmslow Road, Manchester, 20.

1944. Miss Mary Winstanley, 6, Caldy Road, Pendleton, Salford, 6.

1920. J. C. Withers, Ph.D., A.R.I.C., The Shirley Institute, East Didsbury, Manchester, 20.

1945. Professor B. A. Wortley, Faculty of Law, The University, Manchester, 13.

1915. Lord Simon of Wythenshawe, "Broomcroft," Ford Lane, Didsbury, Manchester, 20.

1923. G. E. Yarrow, M.B.E., M.Sc., A.R.I.C., "Dayspring," 13, Lynton Park Road, Cheadle Hulme, Cheshire.

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Three Interpretations of Greek Vases.

By T. B. L. WEBSTER.

We possess very large numbers of Attic vases; more than 15,000 have been attributed to more than 400 painters, who were working in Athens between 530 and 380 B.C. Many of them represent scenes of everyday Athenian life, many of them scenes from Greek mythology. A considerable proportion have been found outside Greece itself in South Italy and elsewhere, but there is, as far as I know, no evidence of designing for the export market, except that in the first half of the sixth century Athenian vases sometimes look rather like Corinthian and Spartan vases, and Corinthian vases copy the Athenian orange finish; the Athenians were trying to cut out the Corinthians and Spartans, and the Corinthians were trying to keep their markets, but copying a successful rival is quite different from designing for the taste of a particular foreign market. When the Greek cities in South Italy began producing their own painted vases in quantity (from the last third of the fifth century B.C.), they very soon diverged from Athenian norms of shape and subject. The Athenian vase painters therefore paid no special attention to their overseas customers, although much of their income must have been derived from them; in particular the *kalos* names, celebrating a young Athenian beauty of the moment, can have had no interest for foreign purchasers. It is indeed possible that the overseas market was to some extent a second-hand market. Take two famous vases, the Penthesilea cup found at Vulci and the Pronomos krater found at Ruvo: both would seem to be special orders by an Athenian customer. The cup has a much larger field of decoration than most cups, the colour scheme is more elaborate, the design is obviously dependent on a fresco. The krater celebrated a particular performance of a satyr play in Athens at which the Theban flute-player, Pronomos, played. It is difficult to see how either came to Italy except through the second-hand market. We must therefore assume that normally the Athenian vase-painter painted for the Athenian public, sometimes to a special order but probably more often themes which he chose himself as being interesting, beautiful or amusing, and likely to attract a customer.

I want to consider the vase-painter's choice of theme in relation to three vases recently acquired by the Manchester Museum. The first presents no difficulty.[1] Professor Beazley has ascribed it to the Berlin painter, an artist who worked from rather before 500 B.C. till after 460 B.C., and 212 vases (or fragments of vases) by him survive; the treatment particularly of ears, eyes, profile and ankles makes the attribution certain. The shape is the so-called Nolan amphora, a small wine-jar, which according to Beazley[2] was invented about 490 B.C., possibly by the Berlin painter himself. On one side he has painted a Herakles siezing a Centaur whom he is going to kill with his club: the Centaur is already bleeding from arrow wounds. On the other side of the vase a Centaur comes up brandishing a pine tree in his right hand and with a lionskin over his right arm as a shield.[3]

The story of the Centaurs and Lapiths was already known to Homer (*Iliad* i, 263f.; *Odyssey* xxi, 295) and was later represented on the West pediment of Olympia; but Herakles had no part in it. The story of the Centaur Nessos, who tried to violate Deianira while ferrying her across a stream, and was shot by Herakles, appears in Athenian art soon after 675 B.C.[4] and often later; but here the Centaur ally on the reverse excludes this interpretation, as Nessos is always alone. The other famous story of Herakles and the Centaurs is the story of Pholos, which we know first from Stesichorus (5D), a lyric poet of the late seventh to early sixth century. Herakles was entertained by the Centaur Pholos; the other Centaurs smelt the wine and a fight followed; Herakles drove the Centaurs out of Pholos' cave with burning branches siezed from the fire. This is illustrated in detail by a Corinthian kotyle[5] datable 600—575 B.C.; a fragmentary metope from Thermon with part of a Centaur and the name Pholos takes the story back to the third quarter of the seventh century B.C.[6] Centauromachies on Proto-Corinthian

1 Museum No. III.I.40. Description in *Manchester Memoirs*, lxxxvii, 5. Here, pl. 1.

2 *Berliner Maler*, 11.

3 cf. for Centaur with skin: Beazley, *Kleophradesmaler*, pl. 23, 4; Schaal, *Vasen in Frankfurt*, pl. 45b.

4 cf. J. M. Cook, *B.S.A.*, XXXV, 191.

5 Payne, *NC*, No. 941: now illustrated Louvre *Enc. Phot.* I, 266.

6 Payne, *NC*, 129.

vases of the first half of the seventh century show Herakles either shooting down the Centaurs with his arrows or advancing with his sword.[7] Athenian vases sometimes show the beginning of the trouble, the gift of wine[8], and sometimes, as ours, the later stage, but, unlike the Corinthian vase-painters, Athenian vase-painters normally give Herakles club and lionskin or, at least, club (as on our vase) ; the equipment was apparently first given him by Stesichorus[9] and then became traditional.

If we ask what this story meant to the Berlin painter and his public, it is clear that in the fifth century Herakles' fight with the Centaurs was one of the many mythological instances of the battle between the modesty and discipline of the Greek and the violence and brute force of the non-Greek : we have not, I think, a contemporary text for this, but *hybris* is mentioned some sixty years later as the chief characteristic of the Centaurs in the Herakles plays of Sophocles and Euripides.[10] Modesty and discipline are superior to violence and brute force ; this is the meaning of the Herakles story to the Athenians, who had just shown the truth of this in the Battle of Marathon and were to show it again at Salamis ; they are not yet interested in the psychology of Herakles, which formed the theme of the two plays of Sophocles and Euripides.[11] During the past thirty years vase-painters had been increasingly interested in the young Athenian hero, Theseus, who had similar adventures to Herakles and possibly symbolised the young Athenian democracy. It is remarkable that, among the 212 surviving vases by the Berlin painter, no Theseus scene has been identified, but 9 vases have pictures of Herakles, who was a Dorian hero beloved by aristocratic families, some of whom had connections with Sparta.

The second vase[12] is more difficult to interpret. It is a small pelike ascribed by Beazley to Hermonax and discussed by

7 e.g. Payne, *NC*, pl. 7 ; *Protokorinthische Vasenmalerei*, pls. 11, 21.
8 e.g. the Cleophrades ptr., Beazley, *Kleophradesmaler*, pl. 22.
9 See Bowra, *Greek Lyric Poetry*, 112f.
10 S. *Trach.* 1095f. ; E. *H.F.*, 181f.
11 See G. Murray, *Greek Studies*, 106f. ; V. Ehrenberg, *Aspects of the Ancient World*, 144.
12 III.I.41. See description in *Manchester Memoirs*, lxxxvii, 6. Here pls. 2, 3.

Franklin P. Johnson[13] with other late vases by the same painter. Hermonax was a pupil of the Berlin painter and the late vases were painted rather before the middle of the fifth century. On one side (perhaps the front because of the laurel wreath) a young man with a sword drawn pursues a woman; on the other side a bearded man with stick talking to a boy (or woman?) who is wrapped in a cloak and half turns away from him, half towards him; the column shows that the scene takes place inside or in the doorway of a house. The scene on the back may be a scene of everyday life; the scene on the front cannot be. I have seen illustrations of the following parallels: (*a*) lekythos by the Providence painter datable about 480 B.C.[14]; same attitudes and clothes as ours; (*b*) neck amphora by the Sabouroff painter of about 450 B.C.,[15] on the back another woman running away: the young man wears a cuirass and carries his scabbard in his right hand; the woman wears chiton and himation; (*c*) skyphos of about 460 B.C. by the Lewis painter[16]; the young man wears his cloak hanging in front of his body and the girl wears a sakkos; a more important divergence is that, on the other side, a woman with a cloak over her head is being led away by another woman; (*d*) cup (unattributed) of about the same date[17]; youth (as in Lewis painter) pursues woman wearing a chiton and himation; (*e*) pelike near the Hasselmann painter, about 450 B.C., similar [17a]; (*f*) cup by the Carlsruhe painter of about the same date[18]: similar, but the other side of the cup adds a woman running and a king; (*g*) column krater of about 440 B.C. by the Naples painter[19]: similar, a woman wearing chiton and himation moves off to the left of the pair and a king stands on the right; (*h*) cup by Makron about 480 B.C.[20]: Theseus, coming from the light, draws his sword on Aithra, who wears chiton, himation and sakkos.

13 *AJA*, xlix, 491f. See also now *AJA*, li, 233/—.
14 *CVA*, Oxford, i, pl. 38, 8 (Beazley, *ARV*, 434/52).
15 Brit. Mus., V, pl. 64, 2 (Beazley, *ARV*, 559/58).
16 *CVA*, Robinson, pl. 40/2; Smith, *Lewismaler*, 24; Beazley, *ARV*, 517/25.
17 *Compte Rendu*, 1872, 177.
17a *CVA*, Munich, 2, pl. 71, 1 (Beazley, *ARV*, 751/1).
18 Tischbein, I, pl. 21; *ARV*, 513/11.
19 Tischbein, I, pl. 20; *ARV*, 705/17.
20 Pfuhl, *MuZ*, fig. 445; *ARV* 302/11.

PLATE I.

To face page 8.

PLATE 2.

Plate 3.

Plate 4a.

Plate 4b.

Only the Makron cup (*h*) has names and it is so different from the rest that the names do not help us, unless we are prepared to say that the young man in the other scenes is also likely to be Theseus. Professor H. R. W. Smith has interpreted (*c*) as Theseus about to carry off Helen and on the other side Leda alarmed by a servant; this interpretation would also suit (*d*), (*e*), (*f*), and (*g*); in (*f*) and (*g*) the king will be Helen's father Tyndareus. But can we also accept it for our vase and for (*a*) and (*b*) where the young man is dressed differently? "Menelaus threatening Helen" (as on a black-figured amphora in the Manchester School of Art)[21] is tempting, but impossible because Menelaus is always bearded. Orestes and Klytemnestra has been suggested both for the Oxford vase (*a*) and for our vase. Another possibility for our vase is Alcmaeon and Eriphyle, and the reverse might possibly be interpreted as Polyneikes and Eriphyle. The first difficulty is the absence of any inscribed representation on any vase of either Orestes and Klytemnestra or Alcmaeon and Eriphyle. The second difficulty is that the woman is in no way distinguished as the youth's mother; Aithra on the Makron cup at least wears matronly attire of chiton, himation and sakkos, but it must be admitted that Kreousa on the Shuvalov painter's oenochoe[22] is also not distinguished as a matron and there the identification is highly probable. Thirdly, if the woman is Klytemnestra, she should have an axe; if she is Eriphyle, on the back of our vase we should see the necklace[23]. Moreover, a matricide kills; this youth threatens. Certainly the possibility remains that a fresco of Theseus and Helen with Leda, Tyndarus and servants was painted before 480 B.C. and that the vase-painters successively took as much as they wanted of it (sometimes only the youth)[24] and gradually modernised the figures into their own style.

We can perhaps suggest what Hermonax meant in our vase. The two sides are likely to have a connected meaning, because

21 *Manchester Memoirs*, lxxxvii, pl. I, b.
22 Beazley, *ARV*, 753/1.
23 cf. the Chicago painter's picture, Beazley, *ARV*, 408/19. Our man has got his hands on his shoulders and the woman holds nothing under her cloak for which cf. *AJA*, xlix, 498.
24 e.g. *CVA*, Oxford, i, pl. 38/1, Beazley, *ARV*, 510/63.

Hermonax often does give the two sides of his vases a connected meaning. The scene on the front comes ultimately from a mythological picture, perhaps Theseus and Helen ; to Hermonax and his customers it probably meant " young hero threatening woman whom he desires ". The scene on the back is probably " middle-aged Athenian persuading person whom he desires ". So the scenes are connected by a common theme, love-making, and by three contrasts : violence and persuasion, youth and middle-age, the heroic past and everyday present.

The third vase[25] belongs to a group of 41 Athenian white ground vases known as the group of the Negro Alabastra[26], which were painted about 480 B.C. or rather earlier by a painter whom we call the Syriskos painter[27]. Both shape and subject are interesting. The shape is derived from Egyptian perfume vases made of alabaster and in Egypt the shape goes back before 2000 B.C.[28] Two variant forms were copied in clay by the Greeks ; one, almost globular, was first copied in clay by the Cretans, as Professor Demargne of Strasbourg[29] has recently shown, and then by the Corinthians who gradually lengthened it until it became pear-shaped ; the other, more cylindrical, appeared in clay first in Ionia early in the sixth century B.C.[30] and these Ionian alabastra were probably the models for the Athenian potters ; possibly the potters themselves came to Athens from the Eastern Aegean during the sixth century, since the Athenian headvases also seem to have developed from Ionian prototypes[31]. The reason for introducing the alabastron shape must have been the same in Athens and Corinth ; either Egyptian perfume had become so popular that it was imported

25 Museum No. III.I.42. Bought at Sotheby's 10th June, 1947, from the property of Mr. George Dennis. Height 5¾ ins. Here, pl. 4, ab.

26 Beazley, *ARV*, 200 gives latest list and bibliography.

27 Beazley, *J.H.S.*, xlix, 51 : cf. also Haspels, *Bf. lekythoi*, 103 n. 2. The head-kantharos Beazley, *ARV*, 198/42 has a woman by the Syriskos painter on the front and one of our negroes on the back. Two alabastra by the Syriskos painter (Beazley, *ARV*, 197, 34/5) have palm trees exactly like those on many negro alabastra.

28 Angermeier, *das Alabastron*, 12.

29 *Rev. des Et. Anc.* xlii, 106.

30 One example in the Manchester Museum (M.W.I.6956) : see also on *CVA*, Oxford, II D ; pl. I, 27 ; Boehlau, *Nekropolen*, pl. 7, 2 : Angermeier *op. cit.*, 14.

31 Buschor, *Krokodil*, 10. This is also the easiest explanation of the names Lydos and Amasis for Athenian craftsman.

in bulk instead of in alabaster scent bottles or it was actually made on the spot (we know the name of an Egyptian perfumier who lived in Athens at the end of the fifth century)[32].

As far as we know, painted clay alabastra were only made for about eighty years in Athens (about 530—450 B.C.) ; pictures on vases of the late fourth century[33] show alabastra of the same shape, but whether they are of clay or not we cannot tell. The negro alabastra belong to the earliest class which derives directly from the Ionian alabastra ; from about 480 B.C. the shoulder became much flatter and the neck thinner and longer[34]. Within the negro alabastra there are two main variants : ours with knob handles and herring-bone decoration above and below the picture[35] (Nos. 2, 5, 6 in Beazley's list are very like ours, Nos. 4 and 7 have flatter bottoms, No. 32 has a double dog-tooth pattern above and a maeander below the picture, No. 37 apparently has maeander and dog-tooth above and below the picture), the other with no handles, a sharper shoulder, and thick lines above and below the picture (Nos. 1, 3, 14, 15, 22, 23) ; Nos. 17 and 29, which have the second shape, but tongues above the pictures and herring-bone below, stand between the two groups.

Our negro wears a chiton with a linen corslet over it. He carries a round shield with a bull's head charge and hanging piece of cloth on his left arm : he holds a throwing spear in his right hand. Looking back, he runs towards an altar on which a crow is pecking at the leg of an animal[35a]. The inscription *kalos*, beautiful, appears four times : above the handle zone, on the altar, and on either side of the negro : the only other alabastra of the group with *kalos* inscriptions that I have been able to find are Nos. 17 and 32 and the plate No. 40. The inscriptions do not refer to the negro, but to some youth who was a beauty at the time ; the bull's head is the heraldic emblem of the Eteobutadae family and one of them, Lycurgus, was killed at Eion in 476/5B.C. ; he may have been " beautiful " at the time when our vase was painted, but the reference need not be so exact.

32 Strattis, fr. 33 K.
33 e.g. *CVA*, California, pl. 55, 2b.
34 See Haspels, *op. cit.*, 103f.
35 Compare also for shape and decoration the red-figure alabastron with satyr carrying *pelta* with eye, *CVA*, Providence, pl. 17/3 (Beazley *ARV*, 115/54 ; painter of Berlin 2268).
35a cf. Beazley, *Kleophradesmater*, No. 30 (*ARV* 123/33).

Alone of all these negroes ours has a Greek shield and spear and Greek clothing, nor does the altar with the crow appear elsewhere. Most of the negroes wear corslet (twice with shoulder-straps shown Nos. 3 and 23; corslet omitted on 17 and 29), chiton (omitted on 15, 17, 23; on 23 a loin-cloth), sleeves and trousers; two have a long piece of cloth wound round their arms (Nos. 15 and 23). Most have an axe in their right hands (No. 2 has an arrow) and a wide strip of leather (or cloth) over the left arm (Nos 3 and 29 a crescent-shaped shield with an eye as charge; Nos. 2, 13 and 23 a bow). Elsewhere in Greek vase painting (except on the head kantharos by the Syriskos painter with one of our negroes on the back) negroes do not wear trousers or carry axes or short crescent shield. Negroes are not uncommon in Athenian art; they appear in Memnon and Busiris scenes from Exekias' time, wearing loin-cloth or short chiton and equipped with clubs, bows, long curved shield and cuirass[36]; there is also a considerable sequence of negro head vases from about 520 B.C.[37]; finally occasional pictures remain of negro slaves in attendance on Athenians[38], but clearly neither these last nor the headvases can help in the interpretation of our negroes. Trousers[39], sleeved jacket, with or without short chiton or loin-cloth, axe, and short crescent shield, are the normal wear and equipment of Amazons and Persians on vases[40]. The artist has therefore dressed his negroes in the more amusing Amazon/Persian costume; apparently he proceeded through three stages: (1) Amazon, *not* Persian (on No. 37): tiara, sleeved jacket, short chiton and trousers, and equipped with axe, bow and quiver[41]. The face is in outline and beardless; therefore he thinks of a white woman[42]; (2) negroes (black and with negro profiles) but in complete Amazon costume with tiara, loin-cloth and closely fitting trousers (No. 32); (3) negro without tiara,

36 See for details Fraser, *AJA*, 1935, 35f.
37 See Beazley, *J.H.S.*, xlix, 77.
38 e.g. Copenhagen 125, Ehrenberg, *People of Aristophanes*, pl. XIVa.
39 Normally *not* baggy but cf. perhaps Pfuhl 262, 504 and the much later terracottâs published by P. J. Riis, *Act. Arch.*, xiii, 198.
40 See particularly Gow, *J.H.S.*, xlviii, 144 with Holt, vii, 61 and 64.
41 The quiver is given to a negro on No. 23 and on the Syriskos painter's head kantharos *ARV*, 198/42.
42 So also the different painter of the similar alabastron in Cracow (Beazley, *ARV*, 202; *V. Pol.* pl. 32, 3).

with baggy trousers, and with loin-cloth like the last (No. 17). The normal negro of these alabastra seems therefore to be a creation of the artist, made by dressing and equipping our negro like an Amazon.

If we regard this normal negro as the artists' creation, we still have to ask from what he was created. Did the artist find together in some famous picture our negro with his Greek armour, the Amazon equipped with axe, bow and quiver (No. 37), another with crescent shield, another with the long strip of leather or cloth hung over the left arm, and perhaps yet another falling to the ground like the Amazon on the left of Euphronios' Amazonomachy[43] (to provide a model for the falling negro on the head kantharos)? This seems possible as non-human elements also recur on the alabastra—a palm tree (on many), a table (on many), a cross-legged stool (29), and a Greek helmet (2, 17, 29, 37). An Amazon or Amazons can only belong to a mythological picture and therefore the other figures must be mythological negroes. On an amphora of the third quarter of the sixth century by the Swinger[44] a bearded negro with bow and quiver strides out from between two Amazons. The Ethiopian hero, Memnon, the son of the Dawn Goddess, is always represented at this time as a white man and therefore, Beazley's interpretation as "attendants of Memnon and Penthesilea" must be accepted. It is important for us because it gives another scene in which negro and Amazons were associated. Such scenes probably derive ultimately from the epic poem *Aithiopis*[45], which was composed to follow the *Iliad* and dealt first with the expedition of the Amazons under Penthesilea and then with Memnon and his Ethiopians. The lost picture which our vase-painter knew probably represented a Greek raid on the combined Ethiopian and Amazon camp. They are caught while they are making a sacrifice (the crow on the altar shows that the sacrifice is just over); one Amazon is already a casualty (the prototype of the negro on the head kantharos); others are in retreat; our

43 Beazley, *ARV*, 16/5; Pfuhl, fig. 395.
44 Beazley, *B.S.A.*, XXXII, 16, No. 59.
45 Exekias' neck amphora in London (B209, *CVA*. pl. 49/1) has on either side the two main scenes, the death of Penthesilea and the arming of Memnon.

negro seizes shield and spear, but has not time for the helmet which remains on the table (or stool), but is gradually beaten back ; his Greek armour may have belonged to Antilochus whom Memnon killed and the whole scene be a prelude to Memnon's own fatal duel with Achilles. If this reconstruction is right, we see something of how a Greek vase-painter worked. In our alabastron and the Reggio alabastron (No. 37) he remains close to his original ; then he gradually breaks away to create his normal negro in Amazon costume, an amusing figure and an admirable decoration for alabastra filled with Egyptian perfume.

I must finally acknowledge a debt of gratitude to Professor Andreas Rumpf, who read this in page proof. I have adopted his suggestions wherever possible ; responsibility for errors of fact and opinion remains of course mine.

T. B. L. WEBSTER.

Smoke Abatement.

By C. Metcalfe Brown.

Medical Officer of Health, Manchester.

Atmospheric smoke is a double tragedy. It is a criminal waste of our slender fuel resources and a grave menace to our health and well-being. It is so patently preventable that one can only wonder at the folly and ignorance that have allowed us to neglect this problem for so long. The remedy is at hand, but cannot be applied effectively until it has the strong support of public opinion. Although much has been achieved in enlisting this support, progress has been slow and would have been discouraging but for the enthusiasm of the converted. But the spread of knowledge continues and with the support of the more enlightened local authorities and of government departments, there is good reason to believe that acceleration of progress will soon be here.

Historical Notes on Coal and Smoke

825 (circa) The first known reference to coal—'colu fyres'—is attributed to the Vespasian Psalter (O.E.D.). The coal was probably charcoal, the derivative of the destructive distillation of wood.

1236 (circa) The Newminster Cartulary (Northumberland) refers to 'carbo maris' (O.E.D.).

1253 (circa) A Charter in the reign of Henry III mentions 'secole' (O.E.D.). In these thirteenth century documents there appears to be the earliest known reference to sea-coal, or the equivalent of coal as we know it to-day, as opposed to charcoal. Wood and charcoal were the common sources of fuel before the extensive use of raw coal and for several centuries wood, charcoal, and coal were all used as fuel with an increasing use of coal as the forests of the country were depleted and in many cases destroyed. With the increasing use of coal came increasing atmospheric pollution.

The term sea-coal is of interest. In Old English it meant jet, washed ashore by the sea. Jet is a

variety of cannel coal, the candle or kennel coal of Lancashire, once valued for making lighting gas, but of little value for fuel purposes. Apart from this early meaning, two explanations are given of the term sea-coal :

(*a*) that it was carried as it is to-day by sea in ships, primarily from Tyneside to London ;

(*b*) that it was washed up by the sea from coal deposits exposed on the bed of the sea near the coast, as it still is at Redcar in the North Riding of Yorkshire and elsewhere.

The Oxford English Dictionary hazards no guess about the correct explanation.

1257 Queen Eleanor left Nottingham on account of smoke nuisance.

1306 The execution of an artificer for using sea-coal in his furnace contrary to law.

1578 Craftsmen 'have long since altered their furnaces and fiery places, and turned the same to the use and burning of sea-coal.'

1661 Evelyn[1] was moved to write indignantly and to publish his tract "Fumifugium : Or the Inconvenience of the Aer and Smoake of London Dissipated."

Referring to the production of industrial smoke, he wrote—

"Whilst these are belching it forth their sooty jaws, the City of London resembles the face rather of Mount Aetna, the Court of Vulcan, Stromboli, or the Suburbs of Hell, than an Assembly of Rational Creatures, and the Imperial seat of our incomparable Monarch. For when in all other places the Aer is most Serene and Pure, it is here Ecclipsed with such a Cloud of Sulphure, as the Sun itself, which gives day to all the World besides, is hardly able to penetrate and impart it here ; and the weary Traveller, at many Miles distance, sooner smells, than sees the City to which he repairs. This is that pernicious Smoake which sullyes all

her Glory, superinducing a sooty Crust or Fur upon all that it lights, spoyling the moveables, tarnishing the Plate, Gildings and Furniture, and corroding the very Iron-bars and hardest Stones with these piercing and acrimonious Spirits which accompany its Sulphure ; and executing more in one year, than exposed to the pure Aer of the Country it could effect in some hundreds."

But in spite of this and similar fulminations, smoke pollution continued to increase until it reached its height at the beginning of the twentieth century.

1819 Formal enquiry instituted by Parliament into the erection and use of steam engines and furnaces, having due regard to the public health.

1845 The Railway Clauses Consolidation Act required locomotives to be so constructed as to consume their own smoke.

1875 The Public Health Act, which together with the Public Health (Smoke Abatement) Act, 1926, contained the law of smoke abatement until the enactment of the Public Health Act, 1936.

1890 Simon[2] emulated John Evelyn in condemnation—" . . . see with what apparent indifference our nineteenth-century England acquiesces in a daily-increasing sacrifice of daylight to dirt. There are immense masses of our population — the inhabitants, for instance, of London and of many chief manufacturing towns, who endure without revolt or struggle the extremities of general *SMOKE NUISANCE* ; not only condoning the fact (on which here the argument does not turn) that the nuisance is of painful injury to an appreciable proportion of persons, and in certain states of weather kills many of them ; but further (which is here the point) accepting, as if in obedience to some natural law, that their common life shall in great part be excluded from the pure light of day—that incomparable source of all physical gladness—

by an ignoble pall of unconsumed soot ; and hardly murmuring, in their self-imposed eclipse, that their persons and clothing and domestic furniture are under the incessant grime of a nuisance which is essentially removable."

1899 The formation of the London Coal Smoke Abatement Society.

1909 The formation of the Smoke Abatement League of Great Britain.

1924 The formation of the Manchester and District Regional Smoke Abatement Committee which continues to flourish and is now representative of 80 local authorities.

1927 The formation of the Sheffield and Rotherham Joint Statutory Committee.

1929 The amalgamation of the Coal Smoke Abatement Society and the Smoke Abatement League to form the National Smoke Abatement Society.

1936 The Public Health Act which repealed and re-enacted with extensions, the previous smoke legislation.

1946 The Manchester Corporation Act giving powers to prescribe smokeless zones and to control the installation of industrial furnaces.

The Production and Composition of Smoke

Practically the whole of the smoke in the air of our cities and towns arises from the burning of coal and fuels derived from it and only a small proportion is due to other industrial processes. Complete combustion is essentially a compounding of oxygen with the combustible constituents of coal, the principal ones being carbon, hydrogen and sulphur : the residue being incombustible mineral ash. The main harmful resultant gas is sulphur dioxide.

In incomplete combustion there is, in addition, production of soot, pitch and tar.

The Egerton Report[3] shows the amount of atmospheric pollution caused by the burning of one ton of coal for heating buildings by various methods. The burning of one ton of

bituminous coal produces 0·027 tons of pollution in the form of smoke, the amount produced by other methods of heating being practically negligible. All methods of heating produce an average of 0·003 tons of ash pollution per ton of coal used, except that in the case of electricity double that quantity is produced.

The pollution by sulphur dioxide in tons per ton of coal used in heating either directly by the burning of coal or indirectly by the use of fuel derived from coal, is

Bituminous coal	0·024
Anthracite	0·016
Gas	0·003
Coke	0·014
Electricity	0·025

In other words, the burning of bituminous coal offends chiefly in relation to smoke and sulphur dioxide; and the production of electricity in relation to ash and sulphur dioxide.

The discharge of ash into the atmosphere varies directly with the velocity of flue gases. This is relatively low in domestic flues and high in the case of electricity generating stations where mechanical draught produces high velocities of flue gases. The thick deposit of grit to be found near many electricity generating stations and the transfer of some of it to the eyes, nose and the throat are melancholy and unpleasant reminders of this type of nuisance.

The average sulphur content of British coal is about 1·5 per cent. by weight and of this approximately 80 per cent. is discharged as sulphur dioxide and although in relation to the amount of sulphur dioxide there is little to choose between the delinquencies of the domestic fire and of the generation of electricity, the sulphur gases from power stations undergo such diffusion from the tall power station chimneys, that although the total pollution is not affected, the concentration is much reduced in any particular area.

The Measurement of Atmospheric Pollution

We are all aware of the evil effect in general of smoke pollution of the atmosphere; of the damage to health, metal work, stonework and fabrics; of the extra and unprofitable

work created; and of the waste of fuel of which it is a murky indication, but general impressions are often misleading and not to be compared in value with facts derived from actual measurement when that is possible.

Many local authorities, private firms and individuals take systematic observations on atmospheric pollution and the data so obtained is of much value to the interested section of the public, the planners and the smoke abaters.

The co-ordinating authority for the investigation of atmospheric pollution is the Department of Scientific and Industrial Research. Observations are made systematically at 147 measuring stations in 53 towns and places in Great Britain, and the results are communicated to the Department which publishes them monthly in their Atmospheric Pollution Bulletin.

The measuring apparatuses are of standard type and although they are used for many purposes, their construction and use may best be illustrated by reference to a scientific survey of atmospheric pollution in Leicester carried out by the Department of Scientific and Industrial Research[4]. Reference is also made to some of their conclusions.

The Deposit Gauge

The present form of apparatus for measuring deposit from the air is the standard deposit gauge which collects, by means of a funnel and bottle, the entire material deposited in one month on the surface of the funnel. The deposit gauge consists of an open-topped glass bowl, 12 in. in diameter with vertical sides and sloping bottom, having a central hole and spigot to which is attached a rubber tube connected to a bottle placed underneath. The glass bowl or funnel is supported by a galvanized iron ring and three-legged stand at 4 ft. from ground level and is protected at a distance of 6 in. by a wire screen to prevent pollution by birds.

The instrument is exposed on a site where the deposited matter will be typical of that of the surrounding district and where the instrument will be free from unauthorized interference. In general the gauges are at ground level but in some cases, this not being possible, they are placed on the flat roofs

of buildings. The gauge is exposed for one month and the rain water and deposit collected are removed in the bottle, a fresh bottle being placed in position at the end of each month.

The contents of the bottle may include :

(1) rain and other forms of atmospheric water ;

(2) soluble impurities dissolved in the deposited water ;

(3) soluble impurities deposited on the inside of the funnel dissolved by deposited water and washed into the bottle ;

(4) insoluble matter deposited on the inside of the funnel, most of which is washed into the bottle by atmospheric water ;

(5) insoluble matter washed directly from the air by atmospheric water into the funnel of the bottle.

The following components of the monthly deposit are analysed :

(1) Water.

(2) All dissolved impurities, including sulphur in the form of sulphites and sulphates, chlorine and lime.

(3) Undissolved matter consisting of tarry matter soluble in carbon bisulphide and other combustible matter, not soluble in carbon bisulphide and ash.

The *pH* of the water is also measured.

Like all instruments, the deposit gauge has its limitations from the point of view of accuracy but, nevertheless, a deposit gauge, sited properly, shows results that are reasonably representative of the average deposit of an area. The results are expressed in terms of tons per square mile. Many gauges are needed for measuring the amount of deposit and the greater the number of gauges, the more accurate the results. The most ambitious attempt so far has been at Glasgow where there are 14 gauges.

The collation of results with other evidence such as meteorological observations is of great importance. Examples of variable factors are the amount of rainfall, the direction of the wind, the turbulence of the atmosphere, the regularity of increase or decrease of the emission of smoke from chimneys, seasonal variations and other minor variations, some known

and some not. It follows that our results are far short of being scientifically accurate; nevertheless they are good rough indexes.

The Smoke Filter

The taking of daily samples of smoke is readily accomplished by drawing air from outside a building through a filter paper at the rate of 50 cubic feet per day, with the aid of a small electrically driven pump. The period of sampling is 24 hours and the volume of air is measured with a gas meter. The solid particles collected on the filter paper form a circular stain of one inch in diameter and the weight of pollution in the stain is estimated from readings obtained visually by comparison with a standard scale of shades or photometrically by using a photo-electric cell and galvanometer.

Sulphur Dioxide Apparatus

(*a*) *Hydrogen Peroxide Method*

The mean daily concentration of sulphur dioxide in the atmosphere is estimated by drawing air from outside a building at the rate of 50 cubic feet per day through a bubbler containing hydrogen peroxide, the pH of which has been adjusted to 4·5. Sulphur dioxide is removed from the air to form sulphuric acid which is estimated at the end of the day by titration with a standard solution of sodium hydroxide, to the original pH.

$$H_2O_2 + SO_2 = H_2SO_4$$

$$H_2SO_4 + 2NaOH = Na_2SO_4 + 2H_2O$$

This apparatus has been used for measuring atmospheric pollution since 1931 and a full description of the method appears in a publication[5] of the Department of Scientific and Industrial Research.

It is interesting to note that amongst the earliest investigations on sulphur impurities in the atmosphere are those of Smith[6] whose "minimetric" method of estimating sulphate in water used for washing air is described in the Memoirs of the Literary and Philosophical Society of Manchester.

The sulphur dioxide apparatus may be combined conveniently with the smoke filter by interposing the hydrogen peroxide bubbler between the filter and the air pump.

(*b*) *Lead Peroxide Method*

This method is based on the combination of sulphur dioxide and lead peroxide to form lead sulphate.

$$SO_2 + PbO_2 = PbSO_4$$

A porcelain cylinder is wrapped with cloth which has been impregnated with lead peroxide paste. The cylinder is exposed for one month, the cloth is then stripped off and the amount of lead sulphate is ascertained, the results being calculated in mg. of sulphur trioxide per 100 sq. cm. of exposed surface per day.

The lead peroxide method gives estimates of the measure of chemical activity of atmospheric sulphur, *e.g.* in attack on structural materials. The method also gives an indication of the distribution of sulphur dioxide within and without a defined area. Weather conditions, other than rain, have been found not to effect the lead peroxide cylinders to any marked degree.

Skylight Apparatus

Ultra-violet radiation is of great importance for all forms of life in that it assists in the formation of vitamin *D*. The therapeutic value of this form of radiation has been recognised for many years, *e.g.* in the prevention and treatment of rickets. Atmospheric pollution reduces the amount of sunlight and daylight which should reach the inhabitants of populous areas.

Many attempts have been made to measure natural ultra-violet radiation and the newest and so far most successful, is in the use of an apparatus first designed for the Leicester survey, and described briefly below.

Two translucent fused silica bulbs of differing size are used, the smaller being inside the larger, and the open necks being downwards. A silica quartz disc carrying a uniform deposit of silver is used as an ultra-violet light filter, placed at the mouth of the smaller bulb. Photographic printing paper is placed below this, and between the filter and the paper there is a wedge of optical glass which at the thin end transmits 500 times the amount of ultra-violet radiation transmitted at the thick end. The whole apparatus is suitably supported and shielded. Exposure is made for 24 hours at a time and the resultant prints are matched against standard shades and the results read in arbitrary units.

The technique is an ingenious and highly-skilled process and its inventors modestly state that the instrument "needs to be investigated further and possibly re-designed."

Measurement Results

The aim of the Leicester Survey was to ascertain the distribution of atmospheric pollution in the city and for some distance around the city. Leicester lies in a topographical saucer and is, therefore, relatively free from abnormal climatic conditions. Geographically it is well isolated from other industrial areas. The locality for the investigation was, therefore, well chosen. The observations were made for the years 1937-39.

It was found that the mean smoke distribution at the centre of the city and at a station two miles east of the centre was approximately as follows :

	Centre	*2 miles from Centre*
	Mg. per cu. metre	
Summer	0·17	0·06
Winter	0·42	0·13

The mean distribution of sulphur dioxide was approximately :

	Centre	*2 miles from Centre*
	Volumes per million	
Summer	0·06	0·02
Winter	0·14	0·025

Contour lines of equal pollution produced figures approximating ellipses, the long axes of which lay more or less from north to south, conforming to the layout of the built-up area of the city.

A steady wind did not shift the contour lines more than 1½ miles and the maximum concentration of pollution was never moved from the centre of Leicester for more than half-a-mile. This result, surprising though it may be, explains the remarkable regularity of the contour lines, due allowance being made for the elongation of the city from north to south.

Sunday observations showed that pollution as compared with week-days was lower by 20 per cent. to 50 per cent. The distribution of smoke was also found to be more uniform on

Sundays, doubtless due to the absence of industrial smoke in the central area of the city.

From the observations taken, the empirical rule has been suggested that the smoke concentration in a town is proportional to the square root of its population based on the formula :

$$\underset{\text{(mg./c.m.)}}{\text{Winter mean smoke}} \times 10^4 = \sqrt{\text{Population}} \times (7 \pm 1)$$

In summer, the loss of ultra-violet radiation at the centre of Leicester as compared with observation points 2 miles distant was so small that it was impossible to measure it accurately. The average summer daily ultra-violet radiation was equivalent to 95 standard natural u.v. minutes per day. In winter this was reduced to 20 minutes per day at the centre of the city whilst 2 miles away it was equivalent to 25 minutes per day, a loss of 20 per cent. at the centre of the city.

It is unfortunate that the staff available in the Leicester Survey was insufficient to cover a thorough investigation with regard to deposited matter, but sufficient information was obtained from deposit gauges to justify the conclusion that the undissolved matter, *e.g.* tar, soot and grit diminished with distance from the centre at a rate faster than or comparable with smoke and sulphur dioxide and that the dissolved matter, *e.g.* sulphates, sulphites and chlorides diminished with distance from the centre much more slowly.

The Effects of Smoke

Effect on Health

It must be confessed that there is no scientific proof that smoke has any ill effect on health. The only way to investigate the effect of smoke on health would be to secure two groups, equal in number, of healthy people of similar distribution with regard to sex and age, and to expose one group to smoky air and the other group to smokeless air over a long period of years and then to attempt to assess and compare the state of health of the people in the two groups. Apart from the difficulties involved in measuring health with reasonable accuracy, it is obvious that the other difficulties of such a controlled experiment would make the possibility of achieving it, interesting and informative as it would be, somewhat remote.

Nevertheless, although strict scientific proof is lacking, there is evidence sufficient to convince reasonable men that smoke does have evil effects on health, and this evidence may be divided conveniently into :

(*a*) direct physical effect
(*b*) indirect physical effect
(*c*) psychological effect

(*a*) Direct physical effect. Apart from such minor accidents as the lodgement of grit in the eye, the main effect is on the respiratory system. Fog produces signs of respiratory irritation including cough and catarrh and those signs are produced earlier and more intensely in persons with irritable respiratory mucous membrane, *e.g.* with a disposition to bronchitis. A cold suspension of water such as a Scotch mist will also produce catarrh and cough but it is common experience that when smoke is added, as in town conditions, the resultant fog is much more trying. The presence of smoke, then, aggravates and intensifies the results of irritation caused by combined coldness and wetness.

Cough and production of catarrh are the normal physiological reactions of the respiratory system, but it is axiomatic in medicine that pathological conditions tend to follow constantly repeated abnormal stimuli, in other words, frequent acute attacks tend to produce a chronic condition which may persist even if the acute attacks cease.

And so smoke causes chronic catarrh and bronchitis and their evil sequelae and who, after living in Manchester or other cities with similar atmospheric conditions, will doubt it ?

Sir Alexander Macgregor[7] from his experience as Medical Officer of Health of Glasgow cites the example of " . . . a fog of 74 hours' duration in Glasgow in January, 1929, accompanied by frost and influenza, when the death rate rose to the high figure of 50·3 in the third week of the month as compared with 15·3 per thousand population for the whole year." He also quotes a Leeds experience : "In the first quarter of 1940, the deaths from respiratory diseases were double the average number during the first quarter of any year, in the decennium 1935-45. The beginning of this high prevalence, in the weeks ending January 13th (48 deaths) and 20th (76 deaths),

coincided with and followed a period of frost and dense fog lasting for six days. At Harrogate and Ilkley, twenty miles distant from Leeds and from one another, the temperature ranges were generally lower than at Leeds, but throughout the period the deaths were very few. Comparing fog days, Leeds had thirteen during the first quarter, Harrogate fourteen, and Ilkley nine, so that Harrogate had more "fog" than Leeds and lower temperatures. But the "fog" at Harrogate and Ilkley would not be charged with smoke. Taking Harrogate as 100, Leeds received 50 per cent. and Ilkley 80 per cent. of the recorded sunshine. The difference of death rates, therefore, must be due to the smoke pollution with low temperature and just "mist" and low temperature. This tends to show that "mist" is not highly detrimental to health in respect of respiratory diseases unless smoke pollution is also present."

The possibility of smoke and of exhaust fumes from motor vehicles being causal factors of lung cancer has excited much interest in recent years. Research workers have shown that cancer of the skin and tumour of the lung in mice can be produced by exposure to tar.

Stocks[8] indicates that there has been an increase of certified respiratory cancer mortality during the past 20 years and that lung cancer death-rates in 1921-30 were highest in Manchester, Sheffield, Leeds, Nottingham, London and Birmingham. He also states that in the towns of this country which have the lowest number of mean annual sunshine hours, the mortality figures for lung cancer, bronchitis, respiratory tuberculosis, stomach cancer and other forms of cancer are in each disease group higher than the mortality figures for areas with moderate sunshine which, in turn, are higher than the mortality figures for areas with the greatest sunshine. He comments significantly : "The cause of the differences in annual sunshine is partly geography, partly climate and partly smokiness of the atmosphere."

A report of the Manchester Committee on Cancer in 1941 includes the following :

"*Atmospheric Pollution from Internal Combustion Engines*

The scientific staff for some years had investigated the important problem of the possible effect on health caused by

the exhaust fumes of heavy oil engines which are being so generally used for transport on the public roads. The fumes were found to contain a relatively large amount of soot and tar substances proved to be carcinogenic when applied to the skin. The problem was to ascertain whether they would be likely, if inhaled, to cause cancer of the lungs.

The conclusions arrived at, after three years' observation, were that a prolonged exposure to inhalation of the fumes was liable to cause some irritation of the bronchial passages, but that it is highly improbable that the concentration of such fumes encountered under ordinary conditions of life can play any part in determining lung cancer in man."

It would clearly be unsound to draw any definite conclusion from the evidence from these sources on the relationship between atmospheric pollution and respiratory diseases, but the facts do justify the attitude that the question is still open and that further research is required.

(*b*) Indirect physical effect. Reference has been made earlier to the value of ultra-violet radiation in the synthesis of vitamin *D* in the body. The growing child especially benefits from ultra-violet radiation. The filtering-off by smoke of sunlight and daylight has, therefore, a harmful effect on human beings and on other animals. In the Manchester area, the average annual loss of ultra-violet radiation is about 50 per cent.

It is an extraordinary thing that we, by wasting precious fuel by incomplete combustion, produce smoke which cuts off light and reduces the amount of available vitamin *D* and the other advantages of ultra-violet radiation. Having thus wasted our fuel resources, we spend money to counteract the effect of our improvidence on expensive apparatus to provide ultra-violet light therapy and to add artificial vitamin *D* to dried milk and other foodstuffs.

(*c*) Psychological effect. A new term, psychosomatic medicine, has been coined in recent years, but new though the term may be it applies to the centuries-old conception of the interdependence of mind and body. Mental ill-being produces physical ill-being ; mental well-being is reduced by the gloom caused by both suspended and deposited pollution.

Effect on Vegetation

Smoke causes reduction of light, the accumulation of soot on leaves retards photosynthesis, and the deposition of acids damages foliage.

In investigating the devitalizing effect of smoke Cohen and Ruston[9] found that the fall of leaves was much earlier in the centre of Leeds and the absorption of carbon dioxide by these leaves was less than one-tenth of that of similar leaves outside the town. They found in similar comparisons that radishes and lettuces showed much reduced weight when grown in the centre of the town. The germination of seeds was found to be adversely affected by the acidity of rainwater.

The serious effect of atmospheric pollution on crops may in turn affect cattle through poor pasturage and though it is not possible to assess farming losses due to smoke pollution, it must be considerable.

Effect on Building Materials

The damage to the fabric of buildings is one of the visible effects of smoke pollution. Some very obvious examples exist in the City of Manchester where newly erected buildings rapidly become black. Ship Canal House, the Midland Bank and the Town Hall Extension are examples of buildings which when erected presented an appearance of stainless virginity but are now acquiring a sooty mantle. The tarry deposits adhere to the surfaces and the sulphur acids present in the deposits or brought down by rain react with the stone.

Serious corrosion of metals takes place and it is estimated that the rates of corrosion of iron at Sheffield and of non-ferrous metals in Birmingham are about three times as great as in the country.

The corrosion of metal structures of all kinds necessitates frequent attention and paint maintenance in order to preserve them, and the cost is much greater in polluted areas than in clean districts. Sulphur dioxide has an adverse effect on leather and textile fabrics, when in a concentration of more than 2 or 3 parts per million.

Smoke abatement legislation

The expression of public opinion is often to be found, belatedly perhaps, in legislative action. The current statute of

national application is the Public Health Act, 1936, which contains most of the powers exercisable by local authorities to-day for the abatement of smoke nuisances from industrial sources. The Act requires local authorities to inspect their districts for the detection of nuisances, enables authorities to combine for any purposes of the Act and to carry out investigations into atmospheric pollution and to make bye-laws for the control of smoke. Section 101 of the Act defines as a statutory nuisance (*a*) any installation for the combustion of fuel which is used for any manufacturing or trade process, or for working engines by steam, and which does not so far as practicable prevent the emission of smoke to the atmosphere; and (*b*) any chimney (not being the chimney of a private dwellinghouse) emitting smoke in such quantity as to be a nuisance.

Sections 91, 93 and 94 define the procedure for the service of notices and the power of magistrates to make orders to abate nuisances, including those due to smoke. Section 103 authorises a fine not exceeding fifty pounds for failure to comply with an abatement notice and a fine not exceeding ten pounds for failure to comply with a nuisance order, and a further fine not exceeding five pounds for each day on which the offence continues after conviction therefor. Bye-laws may be made under section 104 for regulating colour, density or content of smoke and building bye-laws may require the provision in new buildings, other than private houses, of such cooking or heating arrangements as are calculated to prevent or reduce the emission of smoke.

The practical application of these measures requires the systematic observation of industrial chimneys for the detection of smoke emissions, by sanitary inspectors.

When a statutory smoke nuisance is detected an abatement notice is served on the occupier of the premises.

The notice lapses at the end of six months if smoke nuisance has not recurred during that period.

If further smoke nuisance is caused during the six months period, the local authority applies to the court for an order to abate the nuisance.

Some local authorities have made bye-laws for regulating the emission of smoke and have adopted the model bye-laws of the Ministry of Health which prescribe that an emission of black smoke for more than 2 minutes in any period of 30 minutes shall be a statutory nuisance. Other local authorities, including Manchester, have not made bye-laws because it has been found in practice that the magistrates in their areas have been prepared to convict on the authority of the smoke clauses of the Public Health Act, 1936, so that bye-laws are unnecessary.

Under the Road Traffic Act, 1930, the Minister of Transport has made regulations governing the construction of motor vehicles with reference to the emission of visible vapour, sparks, ashes and grit. These regulations are administered by the police.

The administration by local authorities of powers relating to smoke nuisances is by no means uniform. This lack of uniformity in administration is one of the causes of the failure to repress much of the industrial smoke pollution in South-East Lancashire. Since smoke is no respecter of municipal boundaries, a local authority which conscientiously carries out its legal obligations may nevertheless be adversely affected by smoke from less energetic neighbours.

In Manchester the control of industrial smoke has been energetically pursued for many years and special smoke inspectors are employed by the Health Committee for this purpose.

A number of local authorities, including Manchester, have found that the powers contained in the Public Health Act, 1936, are inadequate to enable them to deal with smoke from the preventive aspect. They have accordingly secured additional powers through local Acts.

Manchester City Council have obtained important powers for smoke abatement in the Manchester Corporation Act, 1946. These powers involve some new principles in this country. Section 35 of the Act defines an area in the centre of the City which is to be a "smokeless zone" and in which the emission of smoke from any premises will not be allowed. The area is 104 acres in extent and is bounded by Deansgate, St. Mary's

Gate, Market Street, Piccadilly, Portland Street, Oxford Street and Peter Street. The Corporation is empowered to make payments towards the cost of converting the existing fuel burning installations to smokeless operation and powers are given for further smokeless zones to be prescribed. This is the first occasion on which statutory authority has been given for smokeless zones to be established.

Under Section 36 of the Act, the installation of furnaces for steam raising or for manufacturing or trade purposes is prohibited unless they are so far as practicable capable of being operated continuously without emitting smoke.

Any person before installing such a furnace may submit plans and particulars to the Corporation who must indicate within a specified time whether or not they are satisfied that the furnace is capable of being operated without emitting smoke. Where the Corporation have approved proposals or failed to give their decision within the time specified, no proceedings may be taken under the Section against the person concerned. These powers are already in operation in the City but those relating to smokeless zones are not yet in force.

In the U.S.A., bye-laws or smoke ordinances dealing with industrial boiler plant, are almost universal. Such plant may not be installed or altered without permission under licence from the appropriate department and the ordinances are often very specific. For example, mechanical stokers must be installed in plant of over a certain evaporative capacity, portable boilers must use smokeless fuel, stacks must be constructed of stated height to produce the necessary draught and details are given of requirements in the construction of furnaces, admission of air and type of fuel to be used. Plans of all proposals must be submitted for consideration and in a number of cities solid fuel may only be sold under licence and then only if of approved type.

The differing methods of administration of smoke abatement legislation has led to the formation of Regional Smoke Abatement Committees with advisory functions. Complete uniformity of action can be obtained by statutory joint committees for which there is provision in the Public Health Act, but only one statutory committee is in existence—the Sheffield and Rotherham Joint Smoke Abatement Committee.

Regional advisory committees have been set up in Manchester, Bristol, the West Riding of Yorkshire, the Midlands, Greater London and in West Lancashire. The Manchester and District Regional Smoke Abatement Committee, which is the largest, is now representative of 80 local authorities in South Lancashire, East Cheshire and part of Yorkshire and has dealt with many aspects of smoke abatement.

The Committee's activities have included a survey of fuel burning installations in houses in the North-West Region, the organization of courses of instruction for stokers and boiler-house staff, the training of lecturers, and advice and technical assistance to member local authorities with regard to problems in their areas.

There are no legislative powers for controlling the emission of smoke from dwellinghouses. Provision is made in some old Police Regulation Acts and in the power to make bye-laws under Section 249 of the Local Government Act, 1933, to deal with chimneys which have been set on fire, but those enactments are not directed primarily at smoke nuisances.

The practical abatement of smoke nuisances

Smoke nuisances have their origin mainly in industrial installations and domestic fires.

The common factors tending to produce smoke in boiler plant burning coal are :—

(1) Use of too little or too much draught ;
(2) Air entering flues through leaky boiler settings ;
(3) Careless and irregular firing ;
(4) Insufficient boiler plant, tending to overloading in meeting peak demands ;
(5) Unsuitable or inferior fuel ;
(6) Defective plant ;
(7) Any combination of the above.

The steps necessary to deal with these conditions are obvious and do not as a rule involve undue expenditure. Efficient plant, adequate boiler-house instruments and intelligent trained stokers are essential for economical steam raising and prevention of smoke emissions.

The powers possessed by local authorities are a means of securing abatement of smoke nuisances from factory chimneys but the collaboration of manufacturers, managers, engineers and other persons concerned with the operation of boiler plant is essential. As the emission of smoke is indicative of waste, co-operation and mutual understanding in the factory react ultimately to the benefit of the public and reduce operating costs of the boiler plant.

For convenience and other reasons many industrial undertakings have changed to electricity or gas instead of operating boiler plant. This change-over cannot be universally applied to industry particularly where considerable quantities of process steam are required.

It is clear, however, that where electricity or gas has been employed instead of solid fuel plant, there has been a material contribution towards the abatement of smoke, particularly in the case of some metallurgical processes which were notorious offenders in the emission of smoke and noxious fumes. The abolition of smoke from factory chimneys does not remove the whole of the nuisance from industrial sources, because the emission of sulphur dioxide still continues. Grit nuisances are also common. The elimination of sulphur oxides from the flue gases of industrial boiler plant is only practicable in the largest installations and in power stations. The emission of grit and ash is preventable by the use of arresters, of which many efficient types are available.

Fuel often presents difficulties, particularly when low grades have to be taken and used by manufacturers, as at present. Coke is a good smokeless fuel provided that adequate draught is available.

Although the gas and electricity industries themselves contribute some pollution to the atmosphere, their facilities for the carbonization of coal are much more efficient than the average boiler plant used generally in factories. The pollution produced by gas plant and electric power stations must, therefore, be set off against the pollution which is avoided by efficient carbonization in these undertakings instead of elsewhere. Pollution from gas works has been diminished by improvements in retorts, especially by using the continuous

carbonization process, by modern methods of quenching coke and by overall modernization in the operation of gas and coke production. The gas industry is required by statute to remove completely the hydrogen sulphide which forms a considerable portion of the sulphur compounds present. More than half of the organic sulphur compounds remaining are removed during the benzol recovery process at gas works.

Improvements in the design of boilers and mechanical stokers have resulted in great reductions in smoke pollution from electricity generating stations. Very high efficiencies in grit and dust removal are obtained by the use of grit arresters and electrostatic precipitation at practically all power stations, and these installations are required by the Electricity Commission to be installed in all new plant. Local pollution from power stations has been minimized by the use of high chimneys. It is regrettable, however, that the use of gas washing plant which removes almost all sulphur from the flue gases, has been limited to boiler stations at Battersea and Fulham. The cost of installation of gas washing plant and subsequent operation, is high but nevertheless is fully justified in the interests of the public health and should be installed at all power stations.

The abatement of smoke from domestic sources is much more difficult than that of industrial smoke.

Over 80 per cent. of domestic heating is provided by burning bituminous coal in open grates or kitchen ranges. The open coal fire is a very inefficient appliance, its working efficiency being about 20 per cent. The space heating provided by an open coal fire is limited to one room and even then is unsatisfactory.

Cooking arrangements in houses are generally satisfactory but provision for hot water is largely inadequate. The inefficient use of coal in domestic premises in this country is not equalled by any other country in the world. Many houses in the United States, Sweden and Germany, for example, are warmed throughout by some form of central heating with a working efficiency of 40 per cent. to 50 per cent. causing relatively little atmospheric pollution. By contrast, the methods used in Britain cause enormous waste of fuel, high costs to the householder, unsatisfactory service and about half

the smoke pollution of the atmosphere. The remedies for this deplorable state of affairs may be summarised broadly under the following headings :—

(1) by the use of fuels which are smokeless either naturally, *e.g.* anthracite, or by virtue of carbonization, *e.g.* coke ;
(2) by improved cleaning and preparation of coal before distribution so reducing impurities, especially the sulphides of iron ;
(3) by more complete and efficient combustion of bituminous coal ;
(4) by improving the design of domestic appliances utilising solid fuels.

Most of these factors are interrelated and are dependent on economic and other circumstances. The existing grates in the majority of dwellinghouses are not capable of burning natural smokeless fuels such as anthracite, but are capable of conversion for burning coke and similar low temperature smokeless fuels. In recent years there has been large scale research and development on space and water heating appliances suitable for the use of solid fuel, in the average type of house.

As a result of this work there are on the market or in process of development many efficient types of appliance apart from improved open grates, including :

(*a*) openable-closeable stoves—highly efficient closed stoves which may be opened to give an effect of the open fire ;
(*b*) closed stoves such as the anthracite or coke types ;
(*c*) central heating appliances.

These various appliances can be used for heating water as well as for space heating, including the heating of additional rooms by the convection of warmed air.

Great improvements have also been made in the design of solid fuel cookers, combination grates and back-to-back grates. Many of these grates incorporate closeable fires or openable stoves, saving daily relighting, using fuel economically and smokelessly, and reducing household labour and costs.

For intermittent heating, gas and electric appliances offer great advantages. They are smokeless, clean, convenient and

labour saving. Gas and electricity now provide about 15 per cent. of the useful heat in houses. Before the war the rate of increase for the two industries was approximately $1\frac{1}{2}$ per cent. per annum in the case of gas and 20 per cent. per annum in the case of electricity.

It is obvious that these industries are capable of great expansion in the domestic field and it has been estimated that in 20 years' time they will have about 30 per cent. of the market.

Central heating for large houses or blocks of flats and district heating for the supply of heat to a number of buildings involve a relatively large plant. The highest efficiency and smokelessness commensurate with that obtained in a large power station can only be secured for domestic heating by the provision of district heating plants. District heating has been developed in the U.S.A., the U.S.S.R., and in Germany.

The general considerations applicable to particular schemes are outlined in the Interim Memorandum[10] on District Heating of the Department of Scientific and Industrial Research.

Broadly, these are :

(*a*) the size and configuration of the area considered ;
(*b*) the density of buildings ;
(*c*) the amounts and distribution of load ;
(*d*) the availability of the central station in relation to the main load ;
(*e*) the potential difficulties of laying mains.

The principle and practice of district heating are not new. A scheme has been in operation in Dundee for some years and in Manchester for a long period heat has been supplied to adjoining buildings from a power station. A number of local authorities, including Manchester and Westminster, have adopted district heating plans on an ambitious scale, and Urmston has a scheme now in operation supplying more than 1,000 houses.

The abatement and ultimate abolition of smoke from domestic sources is largely a matter of economics and national policy. The average householder is not particularly interested in smoke abatement and central action is necessary by the Government. Education of public opinion, such as that conducted so admirably by the National Smoke Abatement

Society is invaluable. The Fuel and Power Advisory Council appointed by the Minister of Fuel and Power have recently published some extensive and authoritative opinions on the subject and their recommendations are contained in the Simon Report[11] on Domestic Fuel Policy.

The following is a summary of those of the recommendations applicable to our subject :

1. The efficient use of all fuels.
2. The abolition of atmospheric pollution from domestic sources and the greatest possible reduction of the emission of sulphurous gases.
3. The training of stokers.
4. The greatest possible production of smokeless solid fuels.
5. More research on domestic heating.
6. The establishment of information and demonstration centres in the principal cities.
7. The establishment of smokeless zones for experimental purposes.
8. Increased substitution of the use of smokeless solid fuel, gas and electricity for the burning of bituminous coal.

The policy outlined in these recommendations must be pursued with the utmost vigour if satisfactory progress is to be made.

Marsh[12], the General Secretary of the National Smoke Abatement Society, ends his book on the problem of coal and the atmosphere most appositely by quoting the motto of the Smoke Prevention Association of America Inc.—"Smoke has no defence." How right he is and how right they are. Let us adopt that view too and having done so, let us use all the means at our disposal to dispel first, the fog of ignorance, and then the hideous materialized nightmare that overhangs a large part of this country.

And then perhaps, those of us who have fled the smoke and made our homes in the purer air of the countryside, will return to our City and play our proper parts in her social, civic and spiritual life and make our mighty City, mightier still.

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Symposium on Industry and Education.

Held at the Reynolds Hall, College of Technology, Manchester, on November 25th, 1946.

Four papers were presented at this symposium as follows :

(1) Introduction—by J. T. KENDALL, M.A.

(2) The School—by ERIC JAMES, D.Phil.

(3) The Technical College—by J. E. RICHARDSON, Ph.D.

(4) Industry—by K. R. EVANS, M.A.

These were followed by a general discussion. The full text of the second and third papers is printed below.

The School.

By ERIC JAMES.

High Master, Manchester Grammar School.

In a quarter of an hour it is difficult to say a great deal concerning the relationships between the schools and industry. What follows, therefore, is a mere summary of what appear to be the main points, and no attempt has been made to elaborate the arguments into a fully-reasoned essay.

In the first place one central point must be emphasised. The whole problem of the relation between education and industry must be envisaged against the background of a falling population, and a small country with natural resources much lower than those of some other great powers. Seen in this light it becomes quite clear that our greatest national asset is the intellectual capacity of our people. There is evidence that this capacity is not inferior to that of any nation, and is almost certainly being more effectively employed than in most other countries. But it is abundantly clear that we can afford to spare neither effort nor expense in maintaining and improving our educational standards as the pre-requisite of industrial efficiency. I mention the question of expense, since a very great amount of money will be required to implement the educational advances now planned, and it is vital that the industrial community should realise quite clearly and themselves proclaim unambiguously that such expenditure is not in the nature of a luxury or a work of charity to be discontinued in hard times, but the most profitable form of investment that can be undertaken by any highly-organised society.

To approach more detailed questions, we are concerned with the education of three broad levels of ability and aptitude: that of the highest managerial and research groups; that of the executives and technicians; and that of the body of work-people. These roughly correspond with the three types of school, the secondary grammar, the secondary technical and the secondary modern, though the grammar school serves both of the two higher groups. Such a tripartite division of education is in my view justified, at any rate for a number of years. It should, I believe, be pointed out that the industrial and social needs of this country cannot afford to adopt proposals for a common or multilateral school, since this delays the development of the intellectual powers to an extent which can only be tolerated in a country like America where a large population and riches of natural endowment do something to compensate for the inadequacy of the educational system.

I shall be mainly concerned with the grammar school stream which should lead to most responsible industrial positions, but several preliminary points of a general character must be made. Pre-requisites of success in our educational tasks are that there must be no wastage of human capacity at any stage, and as a consequence of this principle, that financial obstacles to an appropriate education for every child must be completely removed. Steps are already being taken to implement this most obvious policy, but once again we must be prepared to recognise the expenditure which is involved.

At all costs we must maintain our academic standards. The point may seem so obvious as to be hardly worth making. Yet there is, in fact, abundant evidence that it is one that cannot be made too often. There are many people to-day, who, in a praiseworthy desire to push forward the wider diffusion of education, feel that the maintenance of the highest standards for the comparative minority capable of attaining them is of secondary importance. There are many who, in attacking an education of a kind which is over academic for the great majority, attack the whole idea of such an education for anyone. This I believe to be disastrous. In my own field of science, for example,

if there is one clear fact about the progress of the subject it is that it rests not upon the supply of competent technicians but upon a stream of pure or long-term researches. We must see that our education is of such a character as to develop the talents of those few people capable of initiating and inspiring such new fields of research. The same is, I believe, true of other subjects.

The technique of assessment of ability and aptitude becomes ever more important as our educational programme develops, and I think that industrialists should recognise this, perhaps by endowments to the appropriate departments of universities, perhaps, as a number do already, by carrying out researches on diagnostic methods with their own employees.

Turning now to the contribution of the highest intelligence groups, i.e. grammar school pupils, to the industrial field we are faced among industrialists with an example of what may be described as belated and partial conversion. The most obvious way in which such education makes its industrial contribution is, of course, through the supply of trained scientists. Yet it has taken two world wars to make industrialists fully aware of the part which academically trained scientists alone can play in industrial progress. That realisation is throwing a very great responsibility on the grammar schools. The Barlow report, prepared by a committee which unfortunately contained no person who could speak for the schools, called for a doubling of the number of academically trained scientists. Certain educational problems follow from this. First : the capacity of the schools to produce them must be examined, and if deficient must be remedied. Secondly : if as is claimed it is possible to expand the universities very considerably without lowering standards, a very great wastage of talent must be occurring during the school years. At once the question suggests itself to any schoolmaster ; at what stage are we losing these potentially gifted children ? At 11, at 16, or at 18 ? It is, in my view, quite essential that a further committee should immediately be appointed to consider these two questions, to which perfectly definite answers must be ascertainable. Those answers quite obviously precede any possible implementation of the Barlow Report, and should have already received investigation.

Thirdly, a move of the centre of gravity of our whole higher education towards Science—a process that is occurring and which the needs of industry will accelerate—raises very acutely the question of the proper balance of scientific education. Scientists are coming to have increasingly important positions in our national life, a phenomenon helped forward by the practice of many firms of transferring men from research to administration. The tendency is to be most warmly welcomed, but it makes it even more necessary that those scientists should be fully educated individuals, alive to other influences than those of the laboratory, and sensitive to the moral and social needs of their time. The means of attaining this are of a too technical and speculative character to be discussed here, but it must be said that industry does not discharge its obligations to the academic life by increasingly lavish expenditure of money on science alone ; there are, indeed, times when I wish that for every pound spent on subsidising scientific work at the universities, another could be spent on subsidising philosophy or medieval history or Greek.

This brings me to my next point. The conversion of industry to a realisation of the value of academic studies has not only been tardy ; it has been partial. The logic of events has forced the industrialist to realise the contribution which a first class scientist can make. He has not been so ready to grasp the fact that the first or second class arts graduate could make no less a contribution at the managerial level. One would have thought that the example of the Civil Service in the last eighty years would have demonstrated that the results obtained by recruiting some of the ablest intellects, whatever their fields of study, and presenting them immediately with problems of an administrative kind are superior to the somewhat haphazard methods of industry, involving the slow and wasteful process of " working one's way up ", or recruitment on the somewhat ambiguous criteria of character and personality. From the headmaster's point of view what is required is an assurance that he can hold out to the ablest individuals in his classical or modern sixth forms the same prospects of secure careers in industry, starting at the administrative level, as in the civil

services or the professions. Such a prospect would both be of immense value to our industrial health and contribute to the problem of maintaining a proper balance in the curriculum of our schools. A further question arises here. Such arts students, whether they are destined for industry or the Civil Service, will be concerned with the administration of a world more and more dominated by the techniques of natural science. It is therefore essential that their general education should include some awareness of the social implications of scientific knowledge. In short we shall only accomplish our ends by seeing our education as a unity in which the various specialisms are fertilised by the consciousness of the values of others, and by a realisation that they are all aspects of one great stream of knowledge. This again is, as it were, a domestic problem for the schools, but it is one that is of such importance for the future of our national life that I must mention it this afternoon.

I have said that to those taking arts courses we should be able to offer a good chance of industrial employment at the administrative level. This raises a question that at first sight may appear trivial but is really of great importance. If industry is to recruit the right boys from the Grammar Schools, either directly or after the University, it must take steps to clarify and publicise its methods of recruitment, particularly at the higher levels. Industry does not yet realise how much weight boys and still more parents put upon a simple and comprehensible account of the way to enter upon a certain career, and a statement of the qualifications required and the prospects opened up. Such a statement issued by a firm, or better a group of firms, giving the facts in clear and unambiguous terms in the form of a short pamphlet disseminated as widely as possible, would do much to attract applicants for industry, as some firms have, of course, realised.

As regards the relationship between industry and other types of school—secondary technical, secondary modern, and the county college—I am not qualified to speak. Nor is it possible for anyone to speak in any detail, for such schools are new and in the case of county colleges non-existent. Their

curricula and their methods will develop of necessity in close association with the needs of industry. It is most urgent, therefore, that the influence of industrial needs upon them should be beneficent. There is a certain danger that pressure may be put upon these schools, particularly the county colleges, to be too narrowly vocational in their aims and methods. It cannot be too clearly realised that the aim of education is something more than the production of employees, and that in serving those larger ends it is actually making a fuller contribution to industrial demands than by a narrower interpretation of its function. In plainer words, the better the quality of the individuals we can produce in our schools the better for industry. This is true of every kind of school, and it will be a short-sighted policy if industry seeks to impose too narrow a vocationalism upon any of them.

These then are the chief needs as I see them ; a recognition on the part of industrialists of the fundamental character of education, and a corresponding willingness to meet ungrudgingly the financial implications of its improvement ; the necessity for the most careful investigation of the methods of selection of children for the various fields of education and for a study of the extent and cause of the wastage of ability which probably occurs at present ; an increasing willingness on the part of industry to attract the most highly trained intellects not only in the scientific field, together with a much wider dissemination of information concerning such opportunities ; and finally, in every field and at every level, a readiness to realise that the long-term needs of industry are identical with those of our national life, and are to be met by individuals educated, and not trained as narrow specialists, with all their abilities developed as effectively and harmoniously as we may.

The Technical College.

By J. E. RICHARDSON.

Principal, Royal Technical College, Salford.

Introduction.

In the fifteen minutes allotted to me for this paper, it is clear that much of great value and significance must necessarily be omitted. In particular nothing will be said respecting the Universities whose contribution in the production of the entrants to the professional class within industry is of very great importance, other than to draw attention to the suggestion that the present output falls well below the need.

In presenting the case of the Technical Colleges, reference will be made to the contribution made by these Colleges in the past and on this basis the problems of the future will be discussed.

1. *The Junior Technical Schools.*

It was the intention of the 1902 Act to promote the development of technical education within the secondary system. In fact, the Royal Commission on Technical Instruction, whose findings resulted in the 1889 Act, laid down the principle that "technical education and secondary education are not distinct and separate entities, but complementary aspects of one whole". The Commission which preceded the 1902 Act reiterated the same view and stated that: "No definition of technical instruction is possible that does not bring it under the head of secondary education, nor can secondary education be so defined as absolutely to exclude from it the idea of technical instruction".

The promoters of the secondary system ignored the views of these two Commissions and achieved the impossible by defining secondary education so as to exclude technical instruction. The loss to industry and to the country is immeasurable and the results of this policy will continue to be felt for many years to come. Technical education was placed administratively under separate regulations, starved financially and its development hindered in every possible way.

* Dr. Richardson has since been appointed Principal of Northampton Polytechnic, London.

There were, however, some enthusiasts who despite the opposition still believed that the Junior Technical School had a vital contribution to make to the economy of a nation so completely wrapped up in industrial and commercial pursuits. In 1913 the schools were first accorded official recognition, but also under the most crippling of regulations. It was categorically stated that they (the Junior Technical Schools) " were not intended to promote the establishment of courses planned to furnish a preparation for the professions, the universities or higher full-time technical work ".

This attitude has now, fortunately, altered, and during the war the then Board of Education encouraged the development of Junior Technical Schools especially for Building Subjects. Even so, the numbers attending such schools only rose from 30,000 in 1938 to 58,000 in 1944. These figures should be contrasted with the number of pupils attending secondary schools which is of the order of 500,000.

Junior Technical Schools should not be confused with trade schools ; they are secondary schools and have been developed as such. For example, the curriculum of the Salford Junior Technical School includes the following subjects :—

English,
History,
Geography,
French,
Mathematics,
General Science.

About six hours per week are devoted to workshop practice, and the only other technical subject is mechanics. All subjects are taught with an industrial bias, but the education given is cultural in the fullest sense.

In the building and textile sections of the schools there is a certain number of trade subjects. Thus, for example, the builders are given craft training in carpentry and joinery, brickwork and plumbing, but it should be clearly understood

that the schools are not training bricklayers or plumbers as such, but pupils are being prepared in an all-round manner for entry into the building industry.

Selection of a particular craft can be made on entry to the industry, with some knowledge at least of a few of the crafts. This should be of considerable advantage to industry, since wrong selections can be minimised.

The accomplishment of these Schools is amazing and is due to several factors, including

(*a*) *Psychological factors.*

Entry is normally at the age of 13+ and by entering a new school, vastly different from previous schools, a new interest and a new zeal is engendered. From feelings of superiority and omniscience pupils are encouraged to see that they have much to learn and that above them there are the Seniors. The fact that they by competition have earned the right to enter such a privileged house of learning is a great stimulus.

(*b*) *Specialised equipment.*

The Senior Colleges within which these junior schools have been developed are normally well equipped with the specialised plant, and apparatus peculiar to the technology, craft or industry concerned. The juniors have access to such of this equipment as is appropriate to their learning and in any case become familiar with, at least by seeing, much of the plant to be met with in the industry.

(*c*) *Specialist teachers.*

Many of the teachers are engaged for service in both the junior and senior departments and are not teachers in the generally accepted sense, but are specialists in their own craft or technology and are engaged for the purpose of imparting some of their skill and experience. The fascination of real craftsmanship is an inspiration to the young learner and is of material value to industry. Many crafts make little appeal until demonstrated, but through demonstration there can be considerable recruitment appeal. For example, in a Junior Technical

School in this area there was a complaint that the mortar trades were failing to attract entrants. A first class bricklayer was engaged on a part-time basis and in the first year seven pupils opted for this trade out of a class of twenty boys.

A measure of the success of these schools is the demand for their products which industry makes. The competition for the boys is keen and the supply is always deficient. Experience has shown that in the main the boys progress well in their craft and are successful in their technological studies. A large percentage stay the course as far as the Higher National Certificate, about which more will be said later and thus they achieve professional status.

A limited number of boys enter the senior full-time department instead of going into industry immediately on the completion of their two years' course. Some take the National Diploma courses which are of a further two years' duration, while others take a School Certificate or Matriculation course. It is astonishing that there is such a high percentage of successes in these courses when the previous background of the boys is taken into consideration. It is normal for a boy to matriculate in one year after the J.T.S. course and to complete a London B.Sc. external degree after a further three years, that is, at the age of 19+. He has thus overtaken and passed his grammar school competitor who normally does not gain University entrance until 18+. That the above is possible is a testimony to the soundness of the education given in their brief two years' J.T.S. Course.

The Future.

With the passing of the 1944 Act, all post-primary education becomes secondary, and three streams are envisaged : Modern, Technical and Grammar. It is vital to the interests both of industry and the nation that a balanced and adequate provision is made in each stream.

The junior technical schools will be taken out of the senior colleges when they are set up as separate secondary schools and there is a very grave danger of irreparable loss unless care is taken to preserve in their new set-up most of those features which promoted the success of these schools in the past.

For all three streams there is the vexed problem of the achievement of real parity in buildings, staffing, equipment, amenities and public esteem, and there is much talk of multilateralism or bilateralism, as the means of ensuring this. For my part I am convinced, and I was happy to hear Dr. James affirm, that multilateralism is not the solution. Technical Secondary Schools should wherever possible be established as separate schools in close association with the Senior College and with a single eye to their real purpose.

The age of entry and methods of selection are not easy to solve and mistakes will be made. My own view is that the age of entry should not be less than 13 and that for the years 11 + to 13 + a common curriculum should be provided, at least for the grammar and technical streams. A little of the classics cannot harm the technical student and some science should be learned by all pupils in this scientific and technical era. Free interchange should be possible over a reasonable range to allow of the correction of wrong selection or choice.

2. *Senior Colleges.*

Industrial staffing can be classified broadly into three streams :

(*a*) The professional class.

(*b*) The technician class.

(*c*) The craftsman class.

Technical Colleges are concerned with all three streams but their main contribution has been with class (*b*).

The volume of the work is not commonly appreciated. Evening work still preponderates ; in the session 1943-44 there were over 1,100,000 students, that is practically at pre-war level. The number released by employers for part-time day classes was 66,000 in 1945, which represents a considerable increase over the pre-war figures. For my own College, the numbers released now are five or six times as many as those released pre-war.

The number of full-time students in technical colleges and art schools is relatively low, being 29,000 in 1945.

The greatest single contribution of the Colleges is probably that made under the National Certificate and Diploma scheme. Though these were introduced almost immediately after the last war (1922) there is still very widespread ignorance of them. The general public knows practically nothing of them. Recently I addressed a parents' association on Technical Education and though most of my audience knew of the School Certificate none had ever heard of a National Certificate, and this within the confines of industrial Manchester. This ignorance is not confined to the man in the street, but is widespread even within the industry. All too often has a proud student flourished his Certificate before a prospective employer only to be dashed to the ground by a remark such as "What is it?" or "Is it the same as a School Certificate?" Ignorance amongst schoolmasters is almost complete!

Well, what is the scheme and what is it for?

Briefly, the National Certificate Scheme was devised to establish a recognised standard of technical education leading ultimately to professional status. The course is normally in two stages covering a total of five years. The Ordinary Certificate, O.N.C., is awarded after three years and represents a basic technician stage while the Higher Certificate, H.N.C., covers a further two years and attains practically degree standard in a limited number of subjects.

The normal age of entry is sixteen years and the qualification for entry is roughly School Certificate or equivalent. Ex-elementary school pupils may qualify for entry by taking two years of a preparatory Senior Technical Course at an evening institute. The courses are arranged either as evening or part-time day courses and occupy approximately 200 hours of instruction per year. Students are necessarily apprentices or trainees in the craft or profession concerned, since the courses are devised against the background of the workshop and craft training given during such apprenticeship or traineeship.

Instruction in theoretical, experimental and practical work is balanced throughout the schemes and though styled National this refers more to the awarding bodies than to the detailed content of the curriculum which can vary widely between the Colleges. The schemes are promulgated locally or regionally and approved jointly by the Ministry of Education and the Professional Institution concerned, thus the Institution of Mechanical Engineers is the joint body awarding certificates in Mechanical Engineering.

The schemes already in existence cover

Electrical Engineering,
Mechanical Engineering,
Building,
Chemistry,
Naval Architecture,
Textiles,
Commerce,
Civil Engineering,
Production Engineering,
Physics,
Metallurgy.

Possession of both Ordinary and Higher Certificates normally exempts the holder from all or most of the graduateship or associate membership examination of the professional Institution concerned. This feature has contributed a great deal to the popularity of the schemes with students.

These excellent schemes are deserving of a wider currency.

Diploma schemes for full-time students are also in existence, but the volume of this work is almost negligible.

Other Courses.

Time does not allow of a description of craft courses, part-time and full-time degree courses, and vocational courses of many types.

The Future.

Important though the contribution of the past to the industrial needs of the country has been, there is need of considerable expansion especially in courses for craftsmen. The accommodation available for the development of part-time day courses and the widening of the scope of the work is woefully inadequate.

Symposium on Intelligence Testing in School and Work.

Intelligence Testing in School and Work.

By STEPHEN WISEMAN.

What does an Intelligence Test Measure?

The work of Binet and Spearman in the early years of this century marked the beginning of a period of experiment and analysis in the field of psychological measurement, a field in which the emphasis has been mainly on intelligence. In spite of the number and variety of different definitions of intelligence the psychologist working in education or in industry has usually emphasised the element of *capacity* or potentiality.

Spearman's work resulted in the postulation of a "general factor" (g) underlying all cognitive activity and behaviour. Although g is correctly described as a "statistical artefact," the hypothesis has been of considerable value, and the methods of analysis developed in Spearman's work enable the educational psychologist to estimate the "saturation" of tests and items, (*i.e.* their relative efficiency as measures of g). Tests highly saturated with g correlate highly with intelligence tests (such as Binet) which have been constructed on the basis of different hypotheses as to the nature of intelligence.

What does measurement reveal?

Intelligence tests administered to a large population reveal a "normal" distribution of scores similar to the distribution of, say height. Intelligence as measured by tests, increases steadily from birth to about the age of 15 or thereabouts, when the curve flattens out. With persons of low intelligence the halt comes earlier : with superior intelligence growth may continue to 16 or 17. Recent research work suggests that measured intelligence may begin to decline from this maximum point in certain occupational groups where no great call is made on intellectual capacity. This is probably further evidence of the impossibility, in fact, of considering g apart from training and environmental factors (such as practice in and familiarity with paper work and verbal and numerical concepts and skills). On the other hand, suggestions that measured intelligence is so dependent upon environment as to make it

useless and misleading are quite obviously exaggerations in the light of evidence from years of research as to the effectiveness of intelligence tests as predictors of success in training and education.

What are the Limitations of Intelligence Tests?

Enthusiasts often make unjustifiable claims, and tend to regard the I.Q. as fixed and immutable. As well as the effects of training and environment already mentioned, tested intelligence may also be considerably affected by temperamental factors. The maladjusted child's score may be profoundly misleading : and the presence of high intelligence is no guarantee that it will be applied effectively in the particular activities considered desirable by educators. Drive and persistence in some individuals may more than compensate for a moderate level of measured intelligence.

As a single basic measure it remains extremely valuable in education and industry as a good predictor of "trainability," but it tells us little or nothing about the special abilities or aptitudes (such as mechanical ability, manual dexterity, etc.) which for certain purposes may be much more important. The value of an intelligence test as one indispensable element in a "battery" of tests for selection or prediction is indisputable : recognition of its limitations is essential for its efficient use.

Intelligence Testing in School and Work.

By J. K. ELLIOT.

Intelligence Testing of Children of School Age.

Intelligence tests or tests of general mental ability are now commonly used in schools, and some of their popularity is due to the claim made on their behalf that they penetrate below the layers of factual knowledge and measure some fundamental factor of the pupil's mental capacity. Such tests are useful as a means of classifying new entrants in secondary schools for whom no general body of factual knowledge can be assumed.

The widespread interest in school record cards is due in some measure to the well-advertised defects of the examination system, but it is also related to the new requirement of the Education Act that a pupil must be educated in accordance with his age, ability and aptitude, a requirement which postulates a detailed study of the individual pupil's abilities and aptitudes. There is as yet nothing approaching general agreement as to what should be entered on a pupil's record card, but the majority of them provide for the recording of general mental ability as measured by a standardised objective test taken on more than one occasion. Preferably the test should be individually applied but group testing is often used. Some years must necessarily elapse before it will be possible to judge whether the school record card system will fulfil the high hopes of its present supporters but it is desirable that there should be early agreement on the group tests to be used because the results of different group tests are not always comparable.

The position in regard to the measurement of special aptitudes is obscure. Should further research support the view at present held by some competent to judge that special aptitudes do not reveal themselves until towards the end of school life, then the school record card will lose some of its promised effectiveness in suggesting the appropriate type of secondary education for a particular pupil. Nevertheless measurements of special aptitudes made late in school life will have a particular interest to those local education authorities which administer the Juvenile Employment Service for the Ministry of Labour.

Although intelligence tests are now used in ordinary schools mainly for internal purposes, there are several branches of a local education authority's work in which reference to the findings of intelligence tests is commonly made. Usually test results are part of a comprehensive collection of data available in respect of a particular child and rarely, if ever, is the intelligence test result by itself of decisive importance.

The child over two years of age with a disability of mind of such a nature or to such an extent as to make him incapable of receiving education at school must be excluded from school,

as must a child whose disability is such as to make it inexpedient that he should be educated in association with other children, either in his own interests or in theirs. Such children must be notified to the Mental Deficiency Acts Authority and once they have been notified a local education authority has neither powers nor duties with regard to them. The procedure for arriving at a decision of such fundamental importance to the future of a child is elaborate and includes many safeguards for the child and the parent, including the right of appeal to the Minister of Education. The child is examined in a most comprehensive way and account is taken of his personal history, his family history, his home conditions, his physical, social and emotional make-up and so on. A part of the examination is a series of intelligence tests, frequently the Terman-Merrill revision of the Stanford-Binet Tests. The tests must be administered by a medical officer, carefully selected on the grounds of personal suitability and soundness of judgment, who has had special training and experience and who has been approved by the Minister of Education for the work. If there are grounds for the least doubt as to the educability of the child, it is usual before reaching a final decision for the child to be given a trial period in a special school so that the teacher's opinion may be added to the evidence.

Distinct from the ineducable are the educationally retarded children, or, as they are nowadays called, educationally subnormal children. A child may be regarded as educationally subnormal if he is so retarded that his standard of work is below that achieved by average children 20 per cent. younger than he is. He may be retarded in his educational attainments because of limited ability, or for other reasons such as prolonged ill-health or unsatisfactory home conditions or unsatisfactory school conditions. The more seriously retarded need to be educated in special schools, whilst the less seriously retarded can be provided for in backward classes in ordinary schools. An intelligence test is a normal feature of the procedure for determining whether a retarded pupil requires education in a special school, since a pupil whose retardation is not entirely due to limited ability may have sufficient recuperative powers for considerate treatment in an ordinary school to be all that

he requires. Because of the possibility of the parent disputing a decision that a child should, in his own interests, go to a special school, it is advantageous for the intelligence testing to follow the same careful lines as when a child is suspected of being ineducable.

Certain rough generalisations, and they are nothing more, may serve to place this problem of ineducable and educationally subnormal children in perspective. Experience suggests that ineducable children have intelligence quotients of less than about 55. A child with an intelligence quotient in the range of 50 to 55 would normally be given a trial in a special school, and if he were a reasonably stable personality and other factors were favourable, the special school might prove the most suitable place for him. The intelligence quotients of educationally subnormal children whose retardation is due to limited mental ability fall in the range 55 to 70 but these limits are not precise. It is estimated that in an urban area about 1·2 per cent. of registered pupils require education in special schools for the educationally subnormal and that the less seriously retarded children may amount in some schools to 8 or 9 per cent. of the registered pupils over the age of seven years.

A recurring problem in educational institutions from the nursery school to the university is the psychologically maladjusted individual. Much can be done for maladjusted children (and indirectly for their classmates) by wise and sympathetic treatment, and many local education authorities have set up Child Guidance Clinics to deal with such cases referred from the schools. The treatment is necessarily individual, for each child is a problem child and an intelligence test is a routine feature of the process of diagnosis. Careful ascertainment of intelligence quotients is desirable if the remedial work of the clinic is not to be frustrated because behaviour disorders in educationally subnormal children are not readily amenable to psychiatric treatment.

A local education authority has certain duties in regard to the Juvenile Courts before which appear offenders between the ages of 8 and 17. Once it has been established that the juvenile has committed the offence with which he is charged, many magistrates ask the local education authority for either a

psychological or a mental report before deciding how the offender shall be dealt with. The reports furnished normally reflect the results of intelligence tests and they may lead the magistrates to send the juvenile to a special school for educationally subnormal children, instead of an approved school.

In the examples so far given, the intelligence tests are individually administered under the best practicable conditions. There remains the use of group tests on the grand scale in connection with the classification of children for the different types of secondary education. A group test of general mental ability is commonly included in the examination taken by children at the age of 11 plus when they are about to pass from the primary to the secondary stage of their education. It is usual for the intelligence test to be associated with attainments tests in English and arithmetic for few would now maintain that classification for secondary education should be determined by intelligence tests results only.

Intelligence tests are now an established part of educational equipment but their results still need to be considered with care and in the light of other information about a particular pupil. Further research and experience may be expected to widen the field in which they can be usefully employed and define more precisely the significance of their results. Intensification of research is accordingly very desirable, but whatever research may achieve it is debatable whether standardised objective tests can by themselves suggest what kind of education is appropriate to a child's abilities and aptitudes. Those who have witnessed the enlargement of mind and enrichment of personality, which some gifted teachers can stimulate, have seen something of the magic of education. Some university teachers and many infant and nursery school teachers have the trick of it, and it is to be hoped that the apparent need for further research work on objective tests will not obscure the fact that the fundamentals of the educational process are but imperfectly understood.

Intelligence Testing in School and Work.

By D. J. CROWTHER.

The question I want to ask myself on your behalf is: "What assistance can intelligence testing technique give to those of us in industry who have to deal with young people who wish to enter industry on the completion of their full time education?"

Immediately we ask ourselves why we should want to have an estimate of the young people's general intelligence at all. One answer—a wrong one which is too frequently given in practice—is something on these lines :—An employer has a vacancy to fill for which he has, say, five applicants. He may say to himself : "Which of these five applicants is the brightest—other things being equal—I will give him the job." Investigations, however, have repeatedly shown, and indeed commonsense reflection tells us that it is as uneconomical, both financially and socially, to pick too good a person for a job as it is to pick too dull a one. In a recent report, published by the Medical Research Council on "The Incidence of Neurosis among Factory Workers," one of the circumstances associated with more than the usual incidence of neurosis is reported to be work requiring skill inappropriate to the worker's intelligence. The sound principle which should be applied is that general intelligence level must be *appropriate* to the occupation for which the applicant is being considered ; or where training is involved the applicant's general intelligence must be appropriate to the proposed training course.

Obviously, the longer and more expensive the training, the more important it becomes to ensure that entrants have the appropriate general intelligence to profit by it. Those who are not bright enough will fail to make the grade—those who are too bright will become bored and dissatisfied and represent a source of wastage. They obviously would have been better employed on work which would make full use of their capacity. I want to make it quite clear at this point that I am not inferring that appropriate general intelligence is the only factor which makes for success in an occupation, but it is an important factor and, moreover, a factor which psychologists feel, with a fair degree of confidence, they can measure with reasonable accuracy.

For these and other reasons, then, we want to have an estimate of the young people's general intelligence. How can we make it? There are three broad main methods—firstly by general impression at an interview; secondly by a study of the applicant's school history—the type of education a young person has received is a rough guide. A study of the degree of success they have attained within that type gives a more accurate picture; and thirdly by intelligence testing.

Intelligence testing has the two important advantages of standardisation and objectivity. Although it would be most unwise to claim absolute accuracy for this method, I feel it is fair to say that of the three it is the most reliable and valid.

But do we in industry need to work to such fine limits? That, I am afraid is a question to which I cannot give a definite answer—I am in the process of trying to find out! We now come to the crux of the matter and I am going to ask yet another question. How in practice do intelligence testing results relate to satisfactory performance in a given occupation? That is a very difficult question to answer and I am afraid I can only attempt but a partial answer by describing to you what we, in our organisation, are doing. We have three broad grades of engineering apprenticeship, corresponding to four educational levels. We have College Apprenticeship, corresponding to the University level, School Apprenticeship corresponding to what, in future I understand, will be known as Secondary Grammar and Public School level, and Trade or Craft Apprenticeship corresponding to the Secondary Technical and Secondary Modern School level. All applicants for these courses are given appropriate tests of general intelligence. The results are recorded on a specially designed record card with all other relevant information. We have then the first side of our equation—the intelligence testing results. The second side of the equation and one which is by far the more difficult to reduce to statistical terms is that of satisfactory, or otherwise, performance in the occupation. We are attempting to define it in terms of specially designed report forms which are completed by the departments in which the apprentices work and by recording progress both in the Works School and local Technical Colleges, and we hope that the

information thus gathered will give us a workable criterion against which to assess the intelligence testing results. The basis of this experiment has been laid down and testing has been going on for about one year, but it is obviously far too early to expect any solid results.

The proof of the pudding is in the eating and we have not yet come to the sweet course. Having, however, my fair share of natural curiosity I have taken the lid off the saucepan to see how the pudding is getting on and there is some evidence that it will not be entirely indigestible. For instance, in one particular intelligence test all boys who obtained a score below 90 have failed in one or more subjects in the Works School terminal examinations. Again, I have found a positive association between intelligence test results and examination results in the Second Year Senior Examination for the Ordinary National Certificate. These are but pointers and it is unwise to read too much into them.

Another interesting feature that I have noted is that on the average, and I emphasize "on the average," our applicants for the College Apprenticeship Course score more highly than applicants for the School Apprenticeship Course, who in their turn score more highly than applicants from Secondary Technical Schools, who again score more highly than applicants from Secondary Modern Schools on the same test. It is tempting to deduce from this that the general intelligence level does decrease when we pass from graduates to secondary modern school leavers. I would emphasize here that the results referred to are corrected for age. Obviously, we do not expect a 15 year old to score so highly as a young man of 20 or 22 years. On the other hand, there is a marked degree of overlap ; a number of boys whose full time education was completed at 14 years of age score as highly as 60 per cent. of the graduates tested.

This would seem to indicate that there is quite a reserve of persons of high general intelligence who do not, for one reason or another, reach the Universities. A recent investigation conducted in Manchester University confirms this.

I am afraid that what I have said represents but a dusty answer to the question I set myself—indeed, I have asked more questions than I have given answers.

It must be emphasized that the science of intelligence testing is, as yet, young and some pure scientists would even say that it is not and never can be a true science. To them I would say this: physicists, who I suppose are students of science in its purest form, can work out (with a very high degree of accuracy) the statistical behaviour of agglomerations of millions of atoms, but they can say nothing precise about the behaviour of one individual atom; psychologists can also make fairly accurate predictions based on large numbers of cases and they can go one better than the physicist in that they can even at this stage make some predictions of value with regard to the individual.

New Antimalarial Drugs.

(*Abstract of Lecture.*)

By F. L. Rose.

The threat of war (1938—1939) led to official action to guard against the cessation of supplies of certain drugs largely manufactured in Germany, involving the elaboration of manufacturing processes by British chemical manufacturers. Amongst other drugs, I.C.I. chemists undertook to study the synthetic antimalarial agents pamaquin (plasmochin) and mepacrine (atebrin), and manufacture was established in time to meet the entry of Japan into the war. The deficiencies of the synthetic compounds and the naturally occurring drug quinine, led to new research designed to achieve a less toxic and cheaper substitute, which in addition would act on forms of the malaria parasite preceding the invasion of the red blood cells and also on the hypothetical exo-erythrocytic (tissue) phase, the persistence of which in the sufferer's body was believed to be responsible for later relapse. For this purpose experimental assay methods had to be developed which would differentiate between the activity of drugs against these several phases of the parasite and also give a fair indication of the degree and range of activity of any drugs selected for test in human malaria. An infection due to P. gallinaceum in chicks was selected, and adapted to provide an accurate yet sensitive test for these properties.

On the chemical side, it was decided to avoid synthesis based on the quinoline and acridine ring systems (present in quinine and pamaquin, and mepacrine respectively) which had been the subject of much abortive research by other workers, and break new ground. The pyrimidine ring system was selected for investigation since it was non-chromophoric and likely to lead to substances of low toxicity, and also because its chemistry had become familiar during a research in which it was incorporated into sulphonamide-type drugs. In addition, certain "basic-side chain" substituted pyrimidines showed tautomeric possibilities equivalent to those discernible in mepacrine. The elaboration of pyrimidine derivatives so substituted and, in addition, carrying the chlorine substituted benzene ring characteristic of mepacrine, led to a substance (2666) showing activity against the blood forms of the parasite

in chick malaria, although too toxic to achieve activity in man. Further development of the working hypothesis gave a new derivative (3349) which was active in man and which appeared to be more suitable than mepacrine for wartime use. Manufacture was put in hand forthwith, but further research on new compounds soon rendered the drug obsolete. The new lead was arrived at by theoretical arguments indicating that an acylic system (biguanide) could replace the structurally similar pyrimidine ring, and moreover the new drugs were, in addition, effective against the tissue forms of the parasite in the experimental disease. Highest activity was achieved in paludrine (N^1-*p*-chlorophenyl-N^5-*iso*propylbiguanide) first made in November, 1944. By December, 1944, activity in man was proved, and in January, 1945, an extensive research in Australia began which demonstrated a high degree of therapeutic activity, and the complete protection from malaria given by small and infrequently administered doses. Low toxicity gave a margin of safety permitting the use of the drug for mass self-medication.

(The above lecture was illustrated by a series of working models demonstrating the development of the tautomeric hypothesis from mepacrine, through 2666 and 3349, and ultimately to paludrine.)

National Industrial Life and the Doctor

(The Perceval Lecture, 1948.)

By RONALD C. LANE, F.R.C.P.,
Nuffield Professor of Occupational Health,
University of Manchester.

The life of Percival gives ample scope to those who are honoured by an invitation to give this lecture. I have little doubt that in future years philosophers and statisticians, public health workers, educationalists and town planners will find their inspiration in his work. I am fortunate in having an unfettered choice, and I unhesitatingly select Percival's contribution to occupational health as the text for my lecture. He was the first of the long line of British doctors who have deeply influenced working conditions in this country.

THOMAS PERCIVAL.

Percival was born in Warrington in 1740. His parents died when he was still a child, leaving him moderately well provided for. He was educated at Warrington Grammar School, came to Manchester Grammar School for a short time, but his health was poor, and he had to return to Warrington, where he came under the influence of a distinguished nonconformist parson named Seddon. This contact resulted in Percival's conversion to Unitarianism, which later prevented him from going to Oxford as he had planned. Instead he became the first pupil at Warrington Academy, which numbered among its teachers several distinguished members of this Society. Later he went to Edinburgh where he studied medicine. At twenty-five he was elected a Fellow of the Royal Society (not, he naïvely points out, by virtue of his published work but through useful influence). He came to Manchester in 1767 and set up house in King Street, where he was to live for the next thirty-seven years and found his family of thirteen. He soon became the leading physician of the North. Writing of him at this time Angus Smith (1883) says :

> " he soon began to think in a manner different from his fellows and to attempt to clear up in his own mind the duties of all members of society towards themselves and especially the poor ".

To such a physician Lancashire in the closing years of the eighteenth century offered a wonderful field and unlimited

scope. The Industrial Revolution was well under way, technological development was becoming increasingly rapid, the hand-driven machines were giving way to those driven by mechanical power, agriculture was losing ground to industry, which was now moving from the home to the factory. Workers who had been static in the rural areas were moving to the rapidly growing, sprawling and insanitary towns of the North and North West. It is probable that of all the changes that followed the great mechanical inventions of the eighteenth century the revolution in the cotton trade was the most striking. Imported cotton at the time of Percival's birth was approximately one and half million pounds per annum, while at the time of his death it had risen to nearly sixty-two million pounds. (Barnes, 1835, Daniels, 1920.)

By 1770 Lancashire had already become the centre of this rising cotton industry and Manchester was becoming completely transformed. Unfortunately this rapid change brought with it many social ills. Both housing and working conditions were bad and the abuse of child labour was appalling.

Percival's attention was early focussed on this last evil, and as early as 1774 we find him condemning in no uncertain terms the exploitation of children in our factories. It was not until some ten years later, however, that an opportunity to arouse public opinion presented itself. An epidemic of typhus fever broke out in Sir Robert Peel's spinning mills, at Radcliffe. The disease spread rapidly and so frightened some of the local landowners that they applied for help to the Manchester Justices who in turn sought the advice of Percival, then an Honorary Physician at the Manchester Royal Infirmary. The recommendations he made are interesting, anticipating as they do certain of the requirements of our present Factories Act. Floors were to be brushed and kept clean. Walls were to be whitewashed at frequent intervals and attention was to be given to ventilation. Hours of work, moreover, were reviewed and recommendations for their drastic reduction were made. Percival's recommendations were much appreciated by the Justices, and the Court gave "public and sincere thanks to him for his help" and "took care that the letter be printed and distributed so that every part of the community may receive the

benefit of their salutary admonitions, a strict attention to which is most earnestly recommended by the Court". (Harrop's *Manchester Mercury*, 1784.)

The Manchester magistrates went further and on the strength of his report passed in 1784 the following resolution :

> "that it is the opinion of this Court that it is becoming highly expedient for the magistrates of this country to refuse their allowances to indentures of Parish apprenticeship in which children are obliged to work in the night or more than ten hours per day. And it is ordered that this resolution shall be transmitted to the clerks of the peace of the counties of Chester, Flint, Denbigh, Stafford, Derby and Westmorland and the different Ridings of the County of York, and that it be also printed in the public newspapers".
>
> (*Manchester Quarterly Sessions Records*, 1784.)

It was to be sixty-three years before the ten-hour act was passed, but it can be justly claimed for Percival that his was the first real attempt to secure this urgently required restriction in the hours of work of children.

In those days of laissez-faire, however, little progress was made towards improved working conditions, until repeated attacks of typhus *scared* the community to action, and an especially severe outbreak in Ashton-under-Lyne and Dukinfield spread to Manchester and gave Percival the opportunity he wanted, and in 1796 we find him the chief speaker at a meeting called at the Bridgewater Arms, as a result of which the famous Manchester Board of Health was formed—" to superintend the health of the poor in the town of Manchester and Salford and the adjacent country".

(" Proceedings of the Board of Health in Manchester, 1805.")

By this time Percival had become convinced that no real improvement could be expected of employers unless some compulsion were applied, and he proposed to the Board of Health that:

> " an application for Parliamentary aid (if other methods appear not likely to effect the purpose) to establish a general system of laws for the wise, humane and equal government of all such works ".

The first of such acts was introduced by Sir Robert Peel—the "Health and Morals of Apprentices" Act. It was a timid measure embracing many of Percival's ideas, but disappointing to him in that it did not go far enough. It was passed in 1802 two years before his death, and was from the first a dead letter. But the influence of Percival did not stop with his death. For some years the effect of his teaching on factory hygiene was felt. During his days here in Manchester Percival fought hard for the apprentice children and did much to prepare public opinion to accept the necessity of legislation to curb the freedom of factory occupiers. He has a fine record of pioneer work in industrial hygiene—he was, in fact, the father of occupational health as we understand it to-day.

CHARLES THACKRAH.

One of the men whom Percival greatly influenced was a young industrialist named Robert Owen who was later to become one of the greatest of our factory reformers. Robert Owen, in turn, was supported by an enthusiastic young doctor named Charles Thackrah, of Leeds, who became deeply interested in the effect of working conditions upon health, and who in 1830 published the results of his researches in his famous book : "The Effects of Arts, Trades and Professions and of Civic States and Habits of Living on Health and Longevity". In the preface he counters the criticism of professional colleagues who, he says :

> "object that the *cure* not the cause or prevention of disease is the business of the medical practitioner"

by maintaining that :

> "a study of medicine which disregards the prevention of disease limits its utility and its honours. It would strip the profession of its noblest attribute that of benevolence and exhibit our practice as influenced more by personal and pecuniary motives than by an anxiety to relieve human suffering and promote human happiness".

Even to-day there are those in our profession who hold the same views, but fortunately they are becoming fewer. Gradually over the last hundred years attitudes have changed and now it is regarded as respectable to show interest in the effect of social and environmental factors upon health.

This book of Thackrah's has been described by Sir John Simon as a contribution to preventive medicine equal in importance with that of Jenner's work on smallpox.

In 1833 (the year after Thackrah's untimely death at 37) the first important Factories Act was passed. It provided protection for children employed in our textile mills, by limiting hours of work, and the age at which they were allowed to enter the mills; it also required twelve hours education each week. Undoubtedly the most important provision made by this Act was for the appointment by the Crown of four Inspectors of Factories to see that the law was carried out. This laid the foundations of the Factory Department, which was to have a profound influence on the promotion of health, safety and welfare throughout the whole world.

THOMAS LEGGE.

From this time on factory legislation grew, but doctors were only able to influence its development from the outside, for it was not until sixty-five years later (a hundred years after Percival's first efforts) that in 1898 Dr. Thomas Legge was appointed the first Medical Inspector of Factories. This time lag occurred despite the warning of several eminent physicians who called attention to the effects of factory conditions on the state of health of the population. The most important of these was probably Sir John Simon, the chief Medical Officer of the Privy Council who, in his now famous reports of 1861 and 1862 complained bitterly of the unhealthy state of our factories when he wrote :

> " the canker of industrial disease gnaws at the very root of our national strength ".

Thomas Legge had been brought up in an academic atmosphere. He was a man of culture who had had the opportunity of studying first hand public health methods on the continent by a prolonged stay in Europe. He immediately set to work to deal with some of the evils of the factories of his time and soon became an expert on industrial disease. Anthrax and lead poisoning were his particular interests and he did a very great deal to eradicate them.

With the appointment of Legge a department was founded which was to grow steadily and to have a profound influence upon the health of the workers in our factories.

As a result of its work regulations governing the dangerous trades were put into force, and attempts were made to educate both employer and employee in all matters related to industrial health and safety. The Factory Medical Department has grown steadily since the beginning of the century, through the pioneer efforts of Legge and his successor John Bridge, and is now an important health force in the field of preventive medicine. There can be little doubt that it has played a vital part in the prevention of industrial disease by the widespread application of a reasonable standard of health, safety and welfare at the place of work.

Modern Developments.

Up to the beginning of the 1914-18 war there were two main periods of development of industrial health. Up to 1850 there was a slow awakening to the new ills of industry, including the long hours and abuses of child labour—while the next period was devoted to accident prevention and the elimination of industrial disease. But with the 1914-18 war there arose a new problem. How to secure and maintain maximum industrial output to meet the greedy demands of a modern war. This situation led to the birth of the Health of Munition Workers Committee, the forerunner of the Industrial Health Research Board, and now for the first time we find some of the physical and psychological problems of industry (as opposed to industrial disease) the subject of scientific investigation by doctors, psychologists and others, who have continued to make great contributions in this field.

In this inter-war period a small but steadily growing number of doctors were appointed to factories to keep people well at their work. With the onset of World War II this number grew very rapidly to reach, in 1946, some 200 whole time and 700 part time doctors with 5,000 nurses. It is interesting to find that this voluntary expansion in industrial health services has been maintained in peace to help industry meet the urgent needs for production with which we are at present faced. It is unfortunate that some of our older industries lagged behind in this new

development. The coal mines, for instance, where the need for medical care was urgent, had no medical service in the inter-war period (except for one Medical Inspector appointed in 1927). It is gratifying to see, however, that the National Coal Board has tackled this problem and is not only setting up a medical service, but is also arranging for research into the human problems affecting this industry. It is a great pity that our own cotton industry should have lagged so far behind in this respect. It is true that at long last it has awakened to the need for attending to its human problems, but so far little use has been made of the help which could be given by the medical sciences. There are, however, in the cotton industry, a few pioneers who are developing industrial medical services, and it is to be hoped these experiments are being watched by the rest of the trade.

Since the last war several large Corporations have set up medical services following the lead given by the Ministry of Supply during the war and now transport, docks, mines and electricity undertakings all have an embryo occupational health service. These are being demanded not only by farsighted industrialists, but also by Trades Unions. There is *no* national industrial medical service in this country, and the decision to wait until our personal health service has been firmly established is—in the light of recent events—a wise one, but it is well to remember that in this respect we lag behind France, which has established a national industrial medical service. Nevertheless it is perhaps wise to experiment before deciding on the final pattern of such a service. Certain parts of industrial medical work overlap personal health service, which might easily provide for some aspects of medical practice in industry, on the grounds that it is more efficient and convenient, as well as being better medicine, to treat certain conditions at work, or near the place of work. Other aspects of this branch of medicine cannot be so regarded and should from their very nature be a direct charge on the industry they serve.

At this point it would be well to outline very briefly the work of the doctor in industry. When I speak of the doctor's work I include the contribution made by those engaged in the basic medical sciences and ancillary services. Anatomist, physiologist,

psychologist and nurse—for without this support no successful attack can be made on the complex and diverse effects of occupational environment on health.

It is well to consider the relationship of these sciences to industry under two heads. Those which ensure that the Worker is fit for the Job, and those, on the other hand, which ensure that the Job is fit for the Worker.

Worker Fit for the Job.

Personnel Selection and Placement.

The pre-placement medical examination is becoming increasingly widely employed. This medical examination is especially useful to offer guidance to those whose physical capacity is below normal—the man with heart disease or with some chest complaint, often has a tragic industrial experience. He usually accepts the first work offered where the wages are suitable, often only to break down in a few weeks or months—to remain disabled for work by illness for varying periods. Too often these men drift rapidly to the industrial scrap heap. The Disabled Persons Employment Act makes it possible to train and find suitable work for certain of these men, but medical guidance on their placement is essential and could prevent many breakdowns, that guidance must be given by doctors who know industry, and who know a great deal about jobs and the stresses and strains they involve. Generally one finds that doctors, unless specially trained, err on the side of excessive caution; this is bad both for the patient and industry.

Such placement medical examinations should not be confined to physical conditions, but must also consider psychological details. The importance of excluding the dull-witted from work which is beyond their capacity was amply proved during the last war, when it was found that if these men were put to work beyond their capacity their health and social adaptation suffered, this was manifested in various ways, they over-stayed their leave or they deserted from the Service. These Army crimes are the Service counterparts of absenteeism and labour turnover of peace-time industry, and there is little doubt that if more consideration were given to psychological competence it would be possible to avoid much ill-health and loss of efficiency.

It is difficult to convince certain workers' organisations of the advisability of such pre-placement medical examinations, and there is some justification for their suspicion, because in the past these examinations have been used to skim the cream off the labour market—such is not the true purpose of the pre-placement medical examination to-day.

Juveniles and Old People.

The entry of the young person into industry, no matter in what capacity, should be regarded as an event of great importance. His powers should be tested and assessed and his development during these vital years should be closely supervised. Medical examination of children entering industry has been provided for by Statute for many years, but far too little use has been made of the opportunities offered. This is a branch of occupational health requiring much more research and much more active liaison between the school services and industry. In the factory we have these children in groups under supervision, at probably the most important period of their lives. We must not be content with limiting their hours of work, we must take full advantage of our opportunities to correct both twists of the body and those of the mind, which later may so gravely affect their Social adaptation.

At the other end of the age scale there are the older people who need medical supervision. The social and economic changes since the middle of the last century have added years to life, we must surely see that life is added to these years and they are not dragged out in enforced and impoverished idleness. The older members of the community must be encouraged to continue at suitable work and so contribute to the national productivity and incidentally to their own upkeep.

Casualty.

Accidents at work are responsible for a great deal of pain and suffering, as well as economic loss. In 1946 there were almost a quarter of a million lost time accidents in factories alone, as well as twenty-five million minor accidents. The first aid treatment of these accidents at the place of work has been required by law for many years, but their ultimate treatment is the responsibility of the personal health service. A close liaison is

needed here, for there is no doubt that by really good first treatment much subsequent medical attention may be saved. Much research has been carried out on the best methods of treating the simple wound in industry, and we do now know the underlying principles on which it must be based. It is important that knowledge of these methods should spread rapidly into industry and that the time lag between research and application should be reduced to a minimum.

Rehabilitation and Resettlement.

The importance of adequate rehabilitation has been emphasised in recent years and the part that work plays in this process cannot be overstressed. It is now recognised that treatment cannot be considered complete until the patient has returned to wage earning work. In the past far too little attention has been paid to this side of treatment, and it has been common to find, following illness or accident, mental and physical deterioration arising from long unemployment. In far too many cases the mental scars resulting from this lack of treatment have been much more ugly than the physical ones resulting directly from the accident. Large industries have shown the value of establishing workshops where patients are able to return to useful productive work at a wage which provides an incentive, and in a factory environment, which is more stimulating to recovery at this stage than the atmosphere of the hospital.

Job Fit for the Worker.

The doctor is greatly interested in environmental conditions encountered at work, both physical and psychological. He is concerned not only with industrial diseases, but also with the less dramatic effect of industrial environment on health and efficiency. He is concerned, for instance, with hours of work, with shift systems, noise, lighting and with temperature and ventilation.

There are still to be found in modern industry special risks giving rise to industrial disease, which raise interesting medical problems and call for close co-operation with engineers and chemists if prevention is to be effective. New substances are constantly being introduced and the greatest vigilance is necessary on the part of the doctor to forestall trouble. I will give a few

examples of industrial diseases—one which has been prevented and two others which have yet to be prevented.

Lead Poisoning. Lead has been recognised as an industrial poison for centuries, and Legge did a great deal to stamp it out in this country. Even so, it has often been left to voluntary effort on the part of the employer to secure adequate protection from lead exposure.

LEAD POISONING IN ELECTRIC ACCUMULATOR WORKS

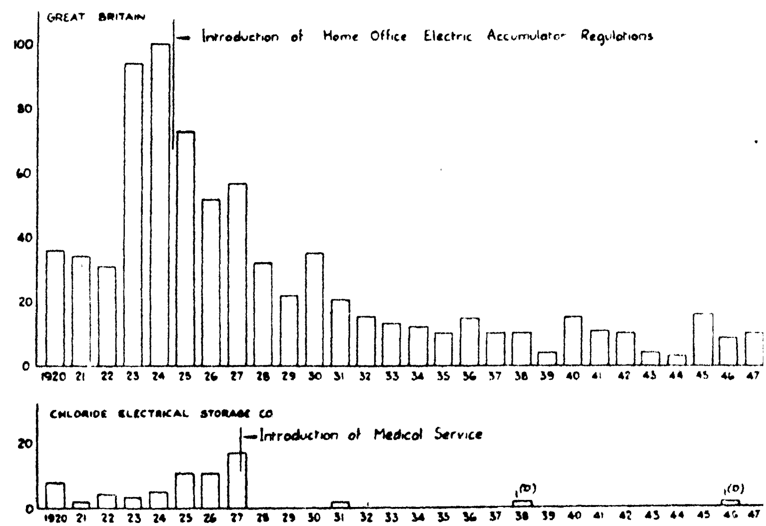

Figure 1 shows the value of a medical service and of specialised supervision in a factory with a severe lead hazard.

In the years immediately following the Great War (1914–18) the demand for electric accumulators grew and the rise in the incidence of cases of lead poisoning caused alarm. In 1924 the Factory Department introduced regulations designed to correct matters. These regulations brought about considerable improvement. In the lower part of the figure the cases of poisoning occurring in the largest accumulator factory in the country are shown, and it will be seen that following the introduction of the Regulations in 1924 the number of cases paradoxically *increased.* This was due to the fact that these regulations were based on the practices of this firm and were designed to extend to the many

the best methods of this industry. Further expansion of business and growth of this factory were alone responsible for the increase in the number of cases, since the introduction of regulations had made no difference to the methods employed. Three years later this firm took a further voluntary step forward and introduced a medical service, with the result that lead poisoning has now been wiped out from this large factory, and methods and standards have been established which make it possible to eliminate it from the whole industry. It is now possible to manufacture accumulators in complete safety, with no injury to health and no reduction in the length of life of those employed.

Industrial Skin Cancer. There are certain materials used in industry which, when repeatedly brought into contact with the skin or mucous membranes, produce cancer. The discovery of mule spinner's cancer in 1906 at the Manchester Royal Infirmary is an example of this disease. The cause is now known to be contained in certain types of oil used in lubricating the spindles, and engineers and chemists soon devised methods to prevent the contamination of the spinner with this oil. This was many years ago but there are still many mules running in Lancashire with no protection for the spinner. Effective prevention can only be brought about by the co-operation of both employers and employees (for medical inspection is often refused by workers themselves). Research and knowledge get us a very little way unless the results are applied to industrial practice.

Pneumoconiosis. In South Wales some 100,000 men work in the pits and 17,000 have been certified as suffering from partial or total disablement as a result of pneumoconiosis (fibrosis of the lung). In two of the pits one man in three has been certified. Now this is a matter of the gravest importance and it is not unnatural that recruitment to the pits in that area is difficult. This problem has a medical aspect of great importance which is now being tackled energetically. Not only is it essential to stamp out this disease because of the unfortunate effects on those who contract it, but also because of the *Fear* which pervades such an industrial community. The miner is a fine type who shows real joy and pride in his work—this, however, is impossible if he is continually haunted by the fear of an insidious disease. Pneumoconiosis can be prevented by adequate dust suppression.

Standards of Safety are being worked out and engineers are doing much to improve conditions but close medical supervision is essential.

Atomic research and the use of new processes in industry, either to prepare radio-active materials or to use them, is likely to need special medical care. It is known, for instance, that ionising radiations can produce profound changes in some of the most highly differentiated body cells, leading to sterility, blood disease or malignant disease. Fortunately the physicists can advise on the protective means necessary, and by the careful design of plant and elaborate monitoring systems no trouble need arise. There was far less trouble, for instance, among the workers engaged in making the atom bombs than in those working on the ordinary high explosive bombs, simply because the danger was foreseen and preventive measures taken.

Here the doctor's part is obvious—research into causes, prescription of safe conditions, and education of employer and employee in safe methods; in this way he can not only play his part in the elimination of the disease but also allay the *Fear* that is not unnatural in the whole working group involved.

MORALE.

In considering the environment it is well to consider some psychological factors which are likely greatly to affect it. The importance of morale in industry has been widely stressed and it is now generally recognised that industrial efficiency and high productivity depend on morale no less than on mechanical equipment.

In the Service unit the doctor was often an important factor in maintaining morale. In industry the medical man has often a similar contribution to make. Properly appointed and with no sectional interest, the doctor who has had the right training and has secured the confidence of employers and workers can be of the greatest value.

His medical training, his knowledge of psychiatry and his position of neutrality make his contribution in the field of human relations an important one. He is likely to see, at an early stage, manifestations of stress, in a way that is denied to those without his advantages. In filling this rôle, however, he must be imbued with a genuine interest in the worker as a person and not merely

as a productive unit. Otherwise he can help but little in improving basic relationships. Increase in production will certainly follow his work, but if the doctor's activities are primarily directed to maintaining the physical integrity of the worker as a machine-minder rather than in giving him that care that the best traditions of the profession demand, full success can never be achieved.

Industry is changing, we have got rid of many of the black spots, but modern conditions (e.g. mass production and huge combines) have brought with them their own problems.

It is the claim of man that he is coming to rely increasingly on reason. But surely all rational activity has purpose, and whilst unbroken rational behaviour might be intolerable (even a professor may want to get drunk), there can be little doubt that the imposition of activities which are not consciously justified and appreciated as purposeful and in some measure creative, gradually undermine the underlying drive towards rationality, which I hold is present in every normal person.

If industry is then to appear a rational proceeding, its purpose must be understood and approved by those who engage in it. It is true, of course, that the degree of understanding will differ enormously, according to the attainments and development of the individual, but purpose must not be lost sight of. No industry can be called a national activity unless, in the pursuit of its ends, it contributes to the evolutionary development of the men and women who make those ends possible. This, I maintain, is a general principle, whatever difficulties may be incident to its application.

In an industrial society, especially one like Britain, it is industry which must take the responsibility for developing the enormous section of the population which it employs, and this development must be interpreted broadly. In other words, industrial life should be national industrial life, with all the responsibilities attaching to the word "national". The responsibility of industry is not fulfilled by handing a workman his pay packet. Industry, when it has engaged labour or skill should regard that labour and skill as a national asset and should foster its further growth as a national duty. This may be idealistic, and we are frightened of ideals, but unless some

common ground is found other than the present horror of impersonal commerce in labour and skill, there will be a continuing waste of both, with discontent and mutual suspicion.

The writings of many progressive industrialists, notably of Urwick, Brown and Reynold, show a full appreciation of this responsibility and of the social purpose of industry. The emphasis now being placed on management training and research shows appreciation of the difficulties of the problem and is the first step forward. Management is a highly complicated function, and can do much to make or mar the quality of the life of those employed, and for its proper prosecution the knowledge and contributions of many experts are required. The recommendations of the committee recently set up by the Minister of Education to consider training for management, are of far reaching importance. One may wish greater stress had been laid on the help that can be given by those trained in the medical sciences who have experience in industry. I submit that the doctor has an important contribution to make in the field of human relations. No longer should he be content to act as a scavenger in a dysgenic social and industrial system, but should be the representatives of a different spirit.

During the nineteenth century the influence of common humanity in politics allowed society slowly to utilise the new teaching which medical sciences made available, and now in the twentieth century the association of social responsibility with urgent economic necessity makes it likely that heavy demands will be made on the medical sciences for assistance in this field. It is right, therefore, that Universities and Medical Schools should show interest in the problems of occupational health. These require not only research of a high order, but the wide dissemination of the results of that research. In approaching this new task it is to be hoped that workers in this field will display the same curiosity, care and courage which marked Percival's work of one hundred and fifty years ago.

ACKNOWLEDGMENT.

I wish to acknowledge the help received from Mr. R. B. Hope for many historical details of Percival's life.

Determinism in Science

(Joule Memorial Lecture, 1948).

BY PROFESSOR SIR GEORGE THOMSON, M.A., F.R.S.
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I feel I owe the Society an apology for attempting to speak on a philosophic subject. I have had no training in Philosophy and speak merely as an experimental physicist, but my subject is one which needs the point of view of someone who has spent his time in the study of phenomena as they appear in the laboratory and not as they are imagined in the study. And since few philosophers have had this training, I may perhaps be excused for venturing into a field for which I am otherwise so ill-prepared.

The controversy between determinism and uncertainty in science is a venerable one dating to the earliest days of scientific thought. The earliest atomists, Leucippas and Democritus, who gave the first picture of the world in the least resembling the views of a modern man of science, seem to have regarded nature as governed by fixed laws, by "necessity" and this was the common Roman view also :— *Aequa lege necessitas sortitur insignes et imos, omne capax movet urna nomen.*

Their successor in the atomistic school, Epicurus (after whom it is usually called) introduced a curious variant, or at least we believe he did. Anyhow, the poem of Lucretius which is believed to represent his views, *De Rerum Natura*, includes in its scheme one very remarkable feature. In speaking* of the motion of the atoms, much in the terms of the modern kinetic theory, he asserts that they do not pursue straight paths but are deflected "at uncertain times and at uncertain points", and this deflection or "declinamen" introduces a random element, makes the atoms collide and makes events happen "for without this, nature would never create anything". It is true that in Lucretius, their theory is mixed up with a misconception of the action of gravity, and that if Lucretius had given his atoms random motions from the start he would have got most of what he wanted, but perhaps this misconception,

* *Quod nisi declinare solerent omnia deorsum,*
imbris uti guttae caderent per inane profundum,
nec foret offensus natus nec plaga creata
principiis : ita nil unquam natura creasset.

by simplifying the problem, enabled him to see more clearly an idea which in our own time has become again a potent catalyst transforming our thoughts into a form as yet hard to guess.

With Newton we enter modern science. His views, or some of them, dominated science till the beginning of this century and later. I was brought up to the view that the world is composed of particles : atoms, molecules, electrons and some more to be discovered, whose motions were bound by inexorable laws, some known and some not, but all presumably of a simple character. The peculiarities of this world were then determined simply by the way in which all these particles had been started off at some remote zero of time, and the whole future could be predicted by a sufficiently competent mathematician who was provided with the exact position and velocity of each particle at the present, or indeed at any other, time. That this was not the whole Newtonian philosophy did not worry me, since the one part of his work, the *Optics*, where any contrary idea is developed, was regarded as the one instance in which his genius had nodded.

Incidentally, of course, this view denied the power of the human will to influence events, and any power of a deity to interfere in the world after he had created it, unless indeed one were prepared to suppose on the one hand that the brain was an exception to the laws governing the rest of matter, or on the other that a deity could transcend time by altering the initial conditions of the Universe after it had started—neither very attractive ideas.

Of course, Newtonian determinism, as I shall call it, had its difficulties and limitations, and it seems worth considering these before going on to the fundamental objection which twentieth-century physics has brought against it. The conception of a super-brain, capable of handling almost infinite complexity, is of doubtful validity. It is obviously impractical and it might well be that, even in principle, such a brain would have to be orders of magnitude larger than the system whose motions it proposed to predict. This brings us to another and perhaps the most important limitation of the Newtonian ideas. To use it, we must be able to separate out the system with which we are concerned, including presumably ourselves, from the rest of

the universe. For if events on the earth are determined primarily by what happens on Betelgeuse we must consult an astrologer for predictions, not a physicist. Even the material of the earth can only be taken into account in the most general sort of way, as providing gravitational and magnetic fields : but it would be hopeless if some peculiar group of atoms inside the earth were to have an important selective effect on the behaviour of things in the laboratory.

This is an important limitation on the nature of the forces. Their effect must fall off rapidly with distance and they must be such that they can be averaged over at least the distant particles, if events are to be determined in more than the most purely theoretical fashion. I shall return to this point later on.

In actual practice the triumphs of Newtonian physics have lain mostly in two directions, astronomical and statistical. Predictions of astronomical position are possible because of the simple character of the law of force and of the convenient constitution of the solar system, with one mass (the sun's) so much larger than all the others. Most laboratory predictions relate to systems in which very large numbers of identical particles are present—the molecules of a gas, the electrons conducting electricity in a wire. Even in optics where the light itself was then regarded as continuous, its detection, whether by the cells in the retina of the eye, or the grains in a photographic plate, involved in practice a statistical measurement. This is an unsatisfactory test of determinism for two reasons. Firstly what is predicted is not a certainty but a probability. As Kelvin pointed out, the water in a kettle placed on a fire may freeze without violating any law of Newtonian physics, but it is most unlikely that it will. Secondly, just the same prediction of probability could have been made without supposing the motion of each individual particle was determined, provided the motion conformed to a suitable law of probability.

Thus as a principle of physics, Newtonian determinism does not get us far. Yet it was, and is, a very important idea and one which has had great influence on the world. It makes a great psychological difference if one believes the world to be determinate. The effects are not perhaps quite what one would suppose.

A belief in determinism does not make men lackadaisical or indifferent, rather it seems to stimulate them to action—to judge at least from the behaviour of the early Mohammedans, of the Calvinists and of the Communists. What would happen to a group which believed that the world was moving inevitably in a direction which it disliked, is hard to say. Perhaps the decline of the Mohammedan nations may give a hint. A more direct effect of determinism in the last century has been to make difficult the relations between science and religion, for to most men at least the idea of moral responsibility is bound up with some idea of free will and difficult to reconcile with a thorough-going determinism.

The discovery of relativity in no way alters Newtonian determinism. The world to the relativist is a bundle of what he calls world lines—tracks in time and space representing the motion of particles and resembling the strings which the designer of railway time-tables uses to ensure that his schedule can be carried on without collisions. These world lines are essentially deterministic. They stretch through time and through space and, once laid down, are fixed. There is nothing to indicate that in the direction of time to come, they are any less precise, any fuzzier, than they were in the past or are in the present.

The coming of the Quantum Theory, on the other hand produced a complete change of view. In a remarkable sense, it, revives the indeterminacy of Lucretius. The path of a particle is no longer a straight line but it may deviate to a degree which is only predictable statistically. Any rigorous statement of the Quantum Theory is necessarily of great difficulty and necessarily mathematical, but one can get a general idea of what is involved by regarding it as a statement of the influence of the observer on what he observes. Every experiment implies an observer without which the experiment is meaningless, since there is no saying what its answer has been. If the observer is a clumsy one he will disturb the effects he sets out to discover ; his clumsy finger impair the delicacy of movement which he seeks to investigate. For a delicate experiment one would of course try to find the most delicate means of investigation—the most delicate

probe with which to discover the effects. The Quantum Theory says, in effect, that there is a limit to the delicacy of probes, or rather, perhaps, that if they become too delicate they become ineffective as probes. It says that one can determine with accuracy *either* position *or* velocity of a particle (more precisely momentum), and *either* time *or* energy but not both simultaneously. No accurate prediction is possible therefore, because we do not know the initial conditions from which the experiment started, and in seeking to determine them we alter them—and that by an unknown amount. The most delicate probes are afforded by Light or Electrons, but even with these there is a limitation to what can be determined. A fair analogy is to think how a blind man, by touch, could discover the way in which the balance wheel of a watch moves, supposing that each time he touched it he brought it to rest. When he let it go, it would start again but probably after an irregular delay. By touching it a number of times, he would indeed discover that it moved, for he would find it in different positions ; but he would not be able to establish that the motion was periodic, or find how many times in the minute it oscillated, for each determination of its position would upset the motion, so that the amount it appeared to move in a given time would be no true indication of its natural motion.

The Quantum Theory " explains " the difficulty by supposing that particles are systems of waves whose wave length is connected with their momentum and that waves are accompanied and associated with particles. The impact of the particles disturbs the system they are used to observe, and the inevitable diffuseness of the waves limits the accuracy of observation. In one sense the particle has supremacy, for it is the particles that produce the effects. At best the waves carry the particles ; usually the waves exist only in thought, but they determine the probability of a particle appearing in any particular place. You see that we are led to a probability, not in this case from statistics, but from a single event. The waves indeed are deterministic but the waves do nothing, and the particles produce the effect and produce it by chance. However carefully the system is prepared, the result is uncertain. To take a concrete example—the paths of

the rays emitted from radium can be made visible in an expansion chamber by condensing little drops of water round the broken atoms which the rays leave in their tracks—this is the famous experiment of C. T. R. Wilson. But if a small speck of radium is placed in the expansion chamber, no one can predict how many tracks will be seen in a particular experiment, nor will the number always be the same. It may perhaps be 5, 6, 8, or even 10 from the same speck under the same conditions. Occasionally, there may be none. This is typical of many types of experiment, particularly those of modern atomic physics. The restriction applies in its full rigour only to events on a small scale. When we are dealing with a large number of atoms, statistics come to our help and prediction becomes possible with accuracy—just as an insurance company can predict with accuracy how many people will die in a particular age group in a particular year, though it cannot predict the survival or death of an individual.

Against this apparent indeterminacy one objection will obviously be raised—is this not merely a question of insufficient knowledge? We are all familiar with events in ordinary life which are unpredictable; a typical example is the tossing of a penny, which is equally likely to come heads or tails, but no one supposes that there is anything mysterious or philosophically important in this. We are convinced that if we knew with just what force the penny was projected and just what resistance it met in the air, we could predict which way up it would hit the table. It is only that the method of projection is uncertain which makes the practice of tossing a tolerable one for settling disputes. It would not be difficult to make a machine which would toss a penny with such accuracy that it would always come up heads. Is not the difficulty with the radium atom soluble in the same way? This explanation is sometimes described as "Crypto determinism". Against this, we can only argue that there is no indication at present of any such hidden mechanism. Attempts have been made to devise one and we can say, at least, that it would be necessarily a very complicated one. Indeed, it has been claimed that we can prove that no such mechanism will suffice. Proofs of this general character, especially proofs of the

negative, are not always very satisfactory, but I think all modern physicists, or nearly all, have a feeling that this way out of the difficulty is unlikely to be correct. It seems contary to ideas which have had a remarkable success.

If we accept the view that the behaviour of atoms and electrons is not deterministic in the sense that it can be predicted, what conclusion does it have for human relations—and in particular for the problem of free will? I feel that it has a very real one. Living matter is very delicately balanced; organisms seem specially designed so that the behaviour of the whole is controlled by the behaviour of a very small part and this is nowhere more so than in the human brain. On almost any view, whether deterministic or otherwise, the behaviour of a man is determined—or at least uniquely associated with—what happens in a few cells in his brain. Now this is just the kind of set-up that is required to allow the probability conceptions of the Quantum Theory to play a decisive role in living matter. If the behaviour of a cell—its division for example—is determined by a small part of that cell, and if the behaviour of a large organism is determined by what happens in a few cells placed in key positions, then the behaviour of a very small number of electrons may control the behaviour of the whole organism, and for these few electrons the probability conceptions of the Quantum Theory are valid without being smudged out by statistics. Lucretius spoke perhaps better than he knew, when after a description of the deflection of atoms, he said, " Hence is that power won from fate, by which we walk each where his wishes lead."*

I am well aware that this view, even if accepted, does not by itself prove the existence of free will. I am not even sure that I am philosopher enough to know what free will means, but it does at least remove the old objection to free will, that matter is governed by fixed laws, which allow of no variation.

* *Denique si semper motus constititur omnis,*
et vetere exoritur semper novus ordine certo,
nec declinando faciunt primordia motus
principium quoddam quod fati foedera rumpat
ex infinito ne causam causa sequatur . . .
. . . unde est haec fatis avolsa potestas
per quam progredimur quo ducit quemque voluntas.

What I have said so far represents a more or less orthodox view; I should like to conclude by putting forward two ideas of a highly speculative character, for which the best I can hope is that perhaps they will lead someone else to the truth in an effort to correct them.

The second law of thermo-dynamics is a fundamental part of the theory of steam-engines. It is used in the most prosaic fashion by engineers every day, but it also has profound philosophic implications, which Sir Arthur Eddington brilliantly discussed. It can be stated in the form that the probability of a system always tends to increase, or at least not to decrease, where probability is understood in a special sense and special rules are provided for calculating it. This is not by any means the platitude it might appear. The probability, in this sense, of some part of the system may diminish, but it will always be at the expense of a greater increase somewhere else. This steady increase in probability is the only kind of process which seems to be going on continuously and without reversal in the universe, so that it marks the passage of time from past to future. Eddington calls it "the arrow of time". The simple laws of physics are all reversible and the elementary processes can go on in either direction. Not so when you consider large and complicated systems to which statistics apply. Here this second law of thermo-dynamics comes in and the change is one of increased probability, at least in the overwhelming majority of cases. The suggestion I would like to make is that what we are dealing with here is not so much an increase in probability as a decay in knowledge. That starting with a certain amount of information which we have obtained somehow or another on the system, any change that the system may undergo must necessarily be one which will decrease our effective knowledge of it, so that what we can assert gets less and less definite. It is in this sense that I would understand the increase of probability. Such a view ties up well with the ideas of the Quantum Theory; indeed if one considers the behaviour of a single electron, it can easily be shown that our knowledge of its position and velocity will decrease from the moment of an observation. In technical language, a wave-packet will spread in motion and the uncertainty of position increases if that of momentum is supposed to remain unchanged.

The other suggestion that I would like to put forward is the following :—There are still difficulties with regard to the elementary theory of particles, even that of a single electron. These difficulties are connected with the mathematical representation which involves infinities which appear very difficult to evade. It is too early to say that these difficulties will be irresoluble, but it is beginning to look as if some rather fundamental change will have to be made. Now up to the present, in considering a scientific problem, one always tries to dissect it out, as it were, from the rest of the Universe, so that one considers the group of bodies in which one is interested—whether they be electrons in a laboratory or planets in the solar system without taking into account the vast complexity of the rest of the Universe. Indeed, if this were not done, it is hard to see how any progress could be made. The Quantum Theory showed that it was necessary to include in the system the observer, as well as what he observed, but it is still assumed that in considering a theory of, for example, a single electron, the rest of the Universe can be, as it were, smoothed out, so that the electron exists in a sort of featureless space. Is this perhaps wrong? Does perhaps the distant Universe really determine events here, and in a way which is more complicated than can be represented by simple gravitational or electro-magnetic fields? Eddington put forward a theory which connected the masses of elementary particles with the size of the Universe and the number of particles in it. If true, this would imply that each elementary particle is influenced by the whole Universe. Again, the fact that we can detect the absolute rotation of the earth, as for example is done by the gyro-compass, and that this rotation can only mean rotation with respect to the mass of the Universe as a whole, suggests the same. If this distant influence can be treated as smooth and averaged out, then it is reasonable to attempt to form a theory of a single electron or two or three. But if this influence is *not* uniform; if for example it produces a kind of erratic graininess in space, then there may *be* no theory of a single electron in the ordinary sense of the term. We may be trying to do the impossible. Perhaps only when the effects are in some way averaged out does prediction become possible. If so, it is not difficult to see that the attempt to produce a theory of the single electron in empty space may lead to contradictions.

On this highly speculative idea I close my lecture.

Ultra-Violet and Daylight Rays in the Solar Cycle

By J. R. Ashworth, D.Sc.

1. In a paper in the quarterly Journal of the Royal Meteorological Society (Vol. LXIX, 302, Oct., 1943) an account was given of the measurement of ultra-violet and daylight rays from the sun and sky and how a record of ten or more years had disclosed a very close relation between the variation of the ratio of the two classes of rays and the variation of sun spots in the solar cycle and how this appears to be intimately connected with the fluctuations of the ionisation of the upper air, investigated by Sir Edward Appleton, which also is sympathetic with the sunspot variation. (Appleton, E. V., 1939, *Phil. Mag.*, Vol. 27, Ser. 7, 144.)

2. *The Light Meter.* The Light Meter used in these observations consists of a metal box 7 in. × 3½ in. in area × 1½ in. deep, the lid of which is fitted with a kind of glass which transmits ultra-violet rays in the near neighbourhood of 3,600 A units of wave length and excludes all visible rays except a weak band in the red. The rays which pass through the glass fall upon a step wedge and then impinge on a piece of sensitive paper and print upon it a graded set of spots corresponding to the steps of the wedge through which the light has been able to pass. By taking the logarithm of the last visible spot a measure is obtained of the intensity of the light. The wedge is made of stepped layers of brass wire gauze of square mesh the layers being diagonally crossed, and from the size of the openings in the gauze its constant can easily be calculated. It can also be experimentally determined. The constant of the wedge used in the observations recorded in this paper is 0·58.

The merits of this wedge are that it does not deteriorate with time and exposure ; it is equally good for measuring rays of long or short wave length ; it has a negligible temperature coefficient ; its constant can be easily and accurately calculated as mentioned above ; and exact copies can readily be made. A calibration of the wedge shows it to be amply good enough for the daily readings.

The sensitive paper is made of a pure material allied to Swedish filter paper and is sensitised by being dipped in a standard solution of pure potassium dichromate and dried in the dark. The paper has the valuable property that it can be at any time reproduced of the same constant sensitivity—a principal reason why it was substituted for the usual photographic paper—and no treatment is necessary if the spots are read as soon as the paper is removed from the meter. Experiments show that the colour depth of the spot marks is proportional to the intensity of the light and the time of exposure. The construction of the step wedge limits the reception of rays to those coming from a circular area of the sky bounded by a zenith angle of 30° to 40°.

If instead of ultra-violet glass in the lid of the meter clear transparent glass is substituted then a range of daylight rays is available and the record is only limited by the transparency of the glass and the sensitivity of the paper on which the rays fall. With dichromated paper the sensitivity extends from the near ultra-violet into the visible spectrum as far as the green, but not as far as the orange and red.

Observations have been made in Rochdale with these meters, placed horizontally, day after day for the last 15 years and, for shorter periods, in Southport and Malvern and other places. The results for Rochdale are briefly set out in the following sections.

Secular Variation of Light Rays.

3. The close relation between the ratio of the ultra-violet (U.V.) and daylight rays (D) and the sunspot number is shown in Figs. 1 and 2. In Fig. 1 the relation between the two is seen in the correspondence of the curves of $\frac{UV}{D}$ and sunspots plotted against the several years from 1932 to 1947, which includes a complete sunspot cycle. In Fig. 2 three years running means of $\frac{UV}{D}$ and sunspots are plotted against one another. The points fall on a line which has a slight curvature the trend of which

shows that the ratio of U.V. to daylight is not quite large enough at the approach of the sunspot maximum to give exact proportionality.

When the component curves of the ratio are examined the feature which is most prominent is the dip of both curves about the time of the sunspot maximum (1937) and their recovery to higher values when sunspots are declining. (See Fig. 1.)

4. Consider first the Daylight Curve in Fig. 1. It begins about 1934, a period of minimum sunspots, to fall from the high value then prevailing and reaches its lowest point at a period of the solar maximum and then rises to a very high point in the year 1944, another period of minimum sunspots, after which it again descends to a low point in 1947, a year of maximum sunspots. The course of the curve is, on the whole, the inverse of the sunspot curve. This inverse relationship suggests that the sun's rays are being obscured in their passage to the earth by a variable element, and it is probable that the variable element is the ionisation of the upper air ; this is, in turn, set up by the ultra-violet rays of the sun reinforced, it may be, by a corpuscular radiation from sunspots or areas surrounding sun spots.

The daylight curve has a single period in the solar cycle like the ionisation curve, and the magnitude of its depression is so large as to make it improbable that there has been any notable increase of visible rays corresponding to the increase of sunspots at the solar maximum. Dr. Pettit* at Mount Wilson Observatory has apparently found very little variation in the intensity of the green ray, emanating from the surface of the sun, in the course of his published observations, extending over seven years, and this is confirmatory evidence for the view that the emission of visible rays is nearly constant. Further evidence for this is given below.

If, for the sake of illustration, we assume that the ionisation of the upper air, which is dependent on the activity of the sun, follows approximately a sine law in the solar cycle and further that the emission of visible daylight rays is nearly of constant intensity, I_{OD}, then we may write :

$$D = I_{OD}\ (1 - d \sin \theta).$$

*Pettit, E., 1932, *Astro-Phys. J.*, Vol. 75, 185—221.

where D is the intensity of the daylight rays incident on the earth at any stage and d a fractional factor determined by the absorption of the rays. Fig. 3 shows that the curve traced from such a formula reproduces the main features of the variation of the rays.

Thus assuming constant emission of daylight rays from the sun and an obstruction to their passage to the earth varying approximately according to a sine law, the fluctuations in their reception on the earth would be accounted for.

5. Considering next the course of the ultra-violet rays (λ 3,600 A) we notice that they have a double inflexion in the solar cycle (see Fig. 3). With the increase in the number of sunspots following the solar minimum of 1933–34 ultra-violet rays increase and soon attain a maximum, and then fall to a pronounced minimum at the maximum of sunspots in 1937: after this, there is a recovery to higher values giving rise to another maximum about 1941–42 and this again is followed by a descent to the lower intensities associated with the lower solar activity in 1944.

It is this double inflexion of the U.V. curve which distinguishes it from the daylight curve.

The minimum of the U.V. curve in 1937 coincides with the maximum of sunspots and the maximum of ionisation in the upper air, and this minimum, like that of the daylight rays, may be accounted for by the absorbing or screening action set up by ionisation. As ionisation varies in sympathy with the sunspots according to an approximate sine law, and is a product of U.V. rays the emission of U.V. rays themselves must vary with the sunspots and follow approximately a sine law. Accordingly, the *emission* of U.V. rays from the sun may be put $I_{OV} \sin \theta$ and the incidence of U.V. rays on the earth may be represented by an equation of the type:

$$\text{U.V.} = I_{OV} \sin \theta \, (1 - c \sin \theta),$$

U.V. being the intensity of the incident rays at any stage, I_{OV} their maximum on emission from the sun, c a constant determined by absorption or scattering of the rays, and $1 - c \sin\theta$ the fraction of the rays passed on after absorption by ionisation.

The equation yields a curve having a double inflexion, when the absorption is large, like the curve of recorded observations (see Fig. 3). Both curves indicate an increase of the U.V. rays with increase of the sun's activity, following the initial minimum, until the growth of the accompanying ionisation forbids any further rise, and a small maximum then occurs. The absorption of the rays by the rapidly growing ionisation accounts for the minimum in the year 1937, and after this, with the diminution of the sun's activity and accompanying ionisation, the rays are less obstructed, reach another maximum and finally fall to another minimum at the succeeding solar minimum. It is important to note that one of the U.V. minima occurs at a solar maximum and the other at a solar minimum.

6. Two features exhibited by the U.V. curve deserve notice. First the range of the fluctuation is small and much less than that of the daylight rays ; secondly there is a period just before the minimum of 1944 when the curves of U.V. and daylight rays move in opposite directions, that is, when U.V. rays are falling, daylight rays are rising, which is in conformity with the sine curves. (See Fig. 3.) With regard to the first feature the percentage range for U.V. rays as shown in Fig. 3 is

$$\frac{102}{504} \times 100 = 20{\cdot}0$$

and for daylight rays, as in Fig. 3, is

$$\frac{4{,}530}{6{,}030} \times 100 = 75{\cdot}0$$

so that the U.V. percentage range is about a quarter of the daylight percentage range.

The theoretical graphs in Fig. 3 show that the range of U.V. rays should be a quarter of the range of the daylight rays.

Both the features mentioned above are consistent with the views put forward which in brief outline are (1) that with daylight rays the emission from the sun is nearly constant and that the rays are impeded, scattered or partially absorbed in their passage

to the earth by a variable layer; and (2) that with U.V. rays the emission from the sun is variable and fluctuates with the fluctuations of the sunspots and that the rays are impeded, scattered or absorbed by a variable layer in the upper atmosphere which is produced by the rays themselves and which varies with the sunspot number.

7. The main result quoted in the opening remarks of this paper showed that the ratio of U.V. to daylight traced year by year, had a variation closely resembling the variation of the sunspots in the solar cycle and, as shown later, followed approximately a sine curve. This result is deducible from the formulas which have been used to represent the incidence on the earth of U.V. and daylight rays. When applied to their ratio we have:

$$\frac{UV}{D} = K\frac{\sin\theta\,(1-c\sin\theta)}{(1-d\sin\theta)}$$

and if c and d are nearly alike in the solar cycle, as may be inferred from the foregoing considerations, then the ratio reduces to :—

$$\frac{UV}{D} = K\sin\theta$$

K being constant and therefore $\frac{UV}{D}$ varies in a similar way to the sunspot numbers in the solar cycle, treating the sunspot numbers as a sine function.

8. The sine functions employed here to portray the general behaviour of sunspots and sunlight treat the rise and fall as taking place symmetrically in the solar cycle. A glance at the sunspot curve shows, however, that there is a departure from symmetry and that the maximum does not occur midway between the beginning and the end of the cycle, in accordance with a pure sine law, but much nearer the beginning so that there is a short rapid rise from the lowest to the highest point, which occupies about three and half years, and a long slow decline from maximum to minimum, which extends over seven or eight years. In the same way the curves of U.V. and daylight and their

ratio depart from symmetry, as may readily be seen in the accompanying figures, and the similarity of their departure from symmetry with that of the sunspot curve emphasises the close correspondence between the sun's activity and the incidence of sunlight on the earth.

SEASONAL VARIATION OF THE RAYS.

9. The changes of intensity of U.V. and daylight rays which take place month by month in the course of the year have a resemblance to the larger and longer changes which take place in the solar cycle.

It should however be noticed that the monthly observations of the two classes of rays treated separately are records of the product of intensity and time, each of them being sine functions, and the varying length of light, month by month, must be taken into account. But where ratios of U.V. to daylight are being considered the time element cancels out.

The observed intensity of the daylight rays in the course of the year increases smoothly from winter to summer and decreases again to the succeeding winter following a sine squared law, but at the height of the summer a depression often occurs in June or July, and sometimes in August, but in that month it is little more than an irregularity in the curve. The midsummer depression in the curve suggests that when the rays of the sun are very powerful, the accompanying ionisation may be dense enough to screen off some of the rays. The diagram (Fig. 4) in which the rate of change of light is plotted month by month shows that the change from June to July exhibits an irregularity during a period of many sunspots in contrast with the regularity of the curve when there are few sunspots which supports this view. But, a possible explanation based on some action in the lower atmosphere must not be overlooked.

Ultra-violet rays behave in a similar way to daylight rays in their annual course, and exhibit at the height of the summer a depression in the curve which traces their variation, and it occurs in most of the years of the solar cycle 1933–44.

10. *Ultra-violet and Daylight rays in Summer and Winter.* The curves shown in Fig. 5 of summer and winter of both U.V. and daylight rays are instructive inasmuch as they supply a confirmation of the influence of an ionic screening layer.

Consider first the *daylight* curve of the four *winter* months. Here the ionisation is weak, and, if we suppose negligible, then there is little or nothing to oppose the passage of the daylight rays to the earth, and we find there is so little fluctuation of the rays that it may be concluded that the intensity of the light is virtually constant. This is in accord with the view that the visible rays are approximately invariable in the course of the solar cycle.

In the next place the *ultra-violet* rays in *winter* time meet with little or no obstruction, and the curve shows that their *emission* from the sun follows a course which is a replica of the sunspot variation, changing from a high point at the sunspot maximum in 1937–38 to a low value in 1944–46, as a *single* fluctuation. This too is in harmony with accepted views of the emission of ultra-violet rays from the sun.

Now consider the *summer* curves when the density of ionisation is generally high and vary much higher than in winter. The daylight curve is strongly depressed below its average when there is a sunspot maximum (1937-38) with its accompanying high ionisation showing that the light is intercepted in a high degree, but at the sunspot minimum (1944) with greatly reduced ionisation daylight rays come through very freely and there is a high point on the curve. The whole curve exhibits an inverse behaviour to the course of sunspots and ionisation, unlike the *winter* curve of daylight.

Lastly observe the ultra-violet curve in summer and notice that the effect of a dense screening layer gives to the curve a *double* inflexion which has been discussed above. It is in strong contrast to the curve of single inflexion where ionisation is small enough to be nearly negligible, as in winter.

The course of the four curves then is evidence for the view that an ionised layer is effective in regulating the passage of light rays from the sun to the earth.

$\frac{UV}{D}$ AND IONISATION IN SUMMER AND WINTER.

11. It has been shown by Sir Edward Appleton* that the ionisation of the upper air changes in close accord with the change of altitude of the sun from winter to summer.

Thus putting λ for the latitude of the place of observation and δ for the inclination of the plane of the earth's equator to the ecliptic and N_S and N_W the number of ions per unit volume in summer and winter respectively, the formula for the ratio is

$$\frac{N_S}{N_W} = \sqrt{\frac{\cos\ (\lambda - \delta)}{\cos\ (\lambda + \delta)}}$$

and for latitude 51°30 where observations have been taken this becomes

$$\frac{N_S}{N_W} = \sqrt{\frac{(51\tfrac{1}{2} - 23\tfrac{1}{2})}{(51\tfrac{1}{2} + 23\tfrac{1}{2})}} = 1{\cdot}85.$$

Records published by Appleton give 1·90 for the average of June to December for the years 1934 to 1938.

Now it is found that the ratio of $\frac{UV}{D}$ from season to season in the course of the year is like the ratio of the ionisation if the light ratio is calculated from December to June, in inverse order to the calculation of the ionisation. Thus we have :

$$\frac{\frac{UV}{D}\ \text{(Winter)}}{\frac{UV}{D}\ \text{(Summer)}} = \frac{1{,}050}{499} = 2{\cdot}10$$

for the average of the years 1934–38 as above, and for the ten years 1932–41 :—

$$\frac{\frac{UV}{D}\ \text{(Winter)}}{\frac{UV}{D}\ \text{(Summer)}} = \frac{2{,}005}{987} = 2{\cdot}04.$$

* Appleton : *Phys. Soc. Proc*, Vol. 52, Part 3, No. 291, p. 402.

The latter observations were made in latitude $53\frac{1}{2}°$ and calculation from the formula for this latitude gives :—

$$\sqrt{\frac{\cos\,(53\frac{1}{2}-23\frac{1}{2})}{\cos\,(53\frac{1}{2}+23\frac{1}{2})}}=1{\cdot}96.$$

The agreement (to 4%) again affords evidence that seasonal light rays may be influenced by ionic density.

When comparing variations of light rays in the annual record it is to be remembered that variations of light intensity month by month are due to the varying altitude of the sun and that any variation of emission from the surface of the sun in so short an interval of time as a month is of little or negligible importance. On the other hand, in the solar cycle the variations of light are the effect of the sun's activity due to intrinsic causes and on the average the varying altitude of the sun does not count. The two modes of light variation may not therefore give strictly comparable results.

Correspondence of $\frac{UV}{D}$ and Geomagnetic Variations.

12. The diurnal inequality of magnetic declination is known to vary proportionately with the sunspot number. The relation is nearly linear and according to Wolf may be put

$$R=a+bS$$

R being the range of declination, S the sunspot number and a and b constants. Since $\frac{UV}{D}$ is also approximately linear with sunspots it is to be expected that $\frac{UV}{D}$ and magnetic range will vary sympathetically. By applying Wolf's secular formula for the magnetic range to the months of the year Chree* has shown that there is a variation from season to season such that winter equinox and summer declination ranges are to one another nearly as the numbers 6 : 4 : 3 for the period examined.

* Chree, *Terrestrial Magnetism*, p. 168.

The numbers he gives for the seasonal ratio $\frac{b}{a}=m$, for quiet days at Kew, when multiplied by 100 are :

Winter	1·00
Equinox	0·65
Summer	0·48

These may be regarded as relative measures of sunspot or ionospheric influence and if the seasonal variation of $\frac{UV}{D}$ is likewise a simple function of sunspot and ionospheric influence there should be a parallel behaviour in the seasonal variations of $\frac{UV}{D}$.

Calculation of the average seasonal values of $\frac{UV}{D}$ for the years 1933–45 gives for the four months of each season :

Winter	0·59
Equinox	0·40
Summer	0·32

When allowances, which are small, are made for the averages of sunspot numbers in the different seasons we get the following relative values 233 : 150 : 114, which reduce to

Winter	1·00
Equinox	0·64
Summer	0·49

These are nearly the ratios found by Chree and they conform to the general ratios 6 : 4 : 3 .

The agreement with Chree's numbers is striking considering that Chree's declination numbers are for the years 1890—1900 and the $\frac{UV}{D}$ numbers are for the years 1933–45. It points to the conclusion that the seasonal variations of the magnetic range of declination and the seasonal variations of $\frac{UV}{D}$ (or its equivalent, the percentage of ultra-violet rays in daylight rays) are controlled by similar agencies. And, as it is agreed that variations of magnetic declination are due to variations in the ionosphere, the probability that variations of $\frac{UV}{D}$ are so, too, is enhanced.

SUMMARY.

What has been written above is an outline of a long record of daily observations of integrated values of the intensity of ultra-violet rays from the sun and sky of wave length $\lambda = 3{,}600$ A and of daylight rays covering a broad band of wave lengths from the green to the near ultra-violet. When the ratio of these two classes of rays is taken, which thereby eliminates certain atmospheric disturbances, it is found that there is a regular fluctuation in the numbers so calculated which follows remarkably closely the fluctuation of the sunspot numbers in the solar cycle.

If now the component curves are examined the course they pursue forcibly suggests that there is an atmospheric variant which is influencing their behaviour. This atmospheric variant agrees in so many respects with an ionised layer in the upper atmosphere that it has been treated as the required atmospheric variant. The possibility that it may be a layer of ozone in the upper regions has not been overlooked, but seems to be excluded on several grounds, a chief one being that it does not absorb the rays which have here been observed.

The inverse relation which is found to hold good between the intensity of the daylight rays and ionic density is so striking that it cannot be disregarded. And the magnitude of the daylight variation is too large to make it at all probable that it is due to the variability in the emission of daylight from the sun. It is more in harmony with the facts that such emission should be nearly uniform from time to time. This is indeed almost demonstrated by the absence of variation in winter daylight when the atmospheric variant is very much reduced, and becomes small enough to be negligible.

Thus the variation of the daylight rays received on the earth may be attributed to a variable atmospheric layer intermediate between the sun and the earth. And the same is true for the ultra-violet rays, taking into account the fact that such rays have their origin around sunspots and are variable in the solar cycle.

That the atmospheric variant may be the ionic layer is rendered the more probable inasmuch as the magnitude of the annual range of the incident rays is of the same order as the magnitude of the variation of the density of the ionised layer which Appleton and his collaborators have demonstrated.

There are no observations in this country nor elsewhere of ultra-violet and daylight rays which have been made in the same way, of the same kind and for the same length of time with which comparisons may be made.

Dr. Pettit of Mount Wilson Observatory began in 1924 to make observations on the U.V. ray λ 3,200 A, and the green ray λ 5,000 A, and published a curve of the U.V. and green ray ratios up to the year 1931. Comparing them with the sunspot curve for the same period he noticed a " considerable correspondence " between the curves, but during the interval June, 1928, to June, 1929, the two curves ran counter, for which he could not assign a reason.

Although he thought there might be " a large atmospheric variant" influencing his results" which may itself depend on U.V. in sunlight " he did not refer to the ionic layer, not then fully investigated, as a probable atmospheric variant which, as shown in this paper, would give rise to the opposite course of the curves of U.V. and sunspots at a period of high solar activity as in 1928-29. He discusses but dismisses the possible influence of ozone in the upper air.

The record which is most nearly comparable to the one given in this paper made with similar meters, registering similar wave lengths, continually for a long period, is one kept at the Fernley Observatory, Southport, and the observations there of $\frac{UV}{D}$ show agreement with the course of the sunspot variation; and a similar record of $\frac{UV}{D}$ kept in the summer months from 1933 to 1942 at Great Malvern, a place very free from atmospheric pollution, is in accord with the Rochdale and Southport observations, and supports the conclusions reached in this paper.

A table of sunspot numbers, ionic character figure (E layer) and the ratio $\frac{UV}{D}$ is appended.

TABLE OF SUNSPOTS, CHARACTER FIGURE (E) AND $\frac{UV}{D}$

Year	Sunspot Number	Character Figure	$\frac{UV}{D}$
1932	11·1	136	1.42
1933	*5·7*	135	***1·04***
1934	8·8	*123*	1·34
1935	36·1	135	1·63
1936	78·8	232	1·73
1937	**115·1**	**249**	**1·85**
1938	109·5	222	1·68
1939	89·7	209	1·57
1940	67·8	184	1·56
1941	47·6	158	1·38
1942	30·8	144	1·23
1943	15·7	138	1·10
1944	*9·9*	***127***	***0·94***
1945	33·0	146	0·98
1946	92·1	211	1·03
1947	**155·8**	**274**	**1·41**

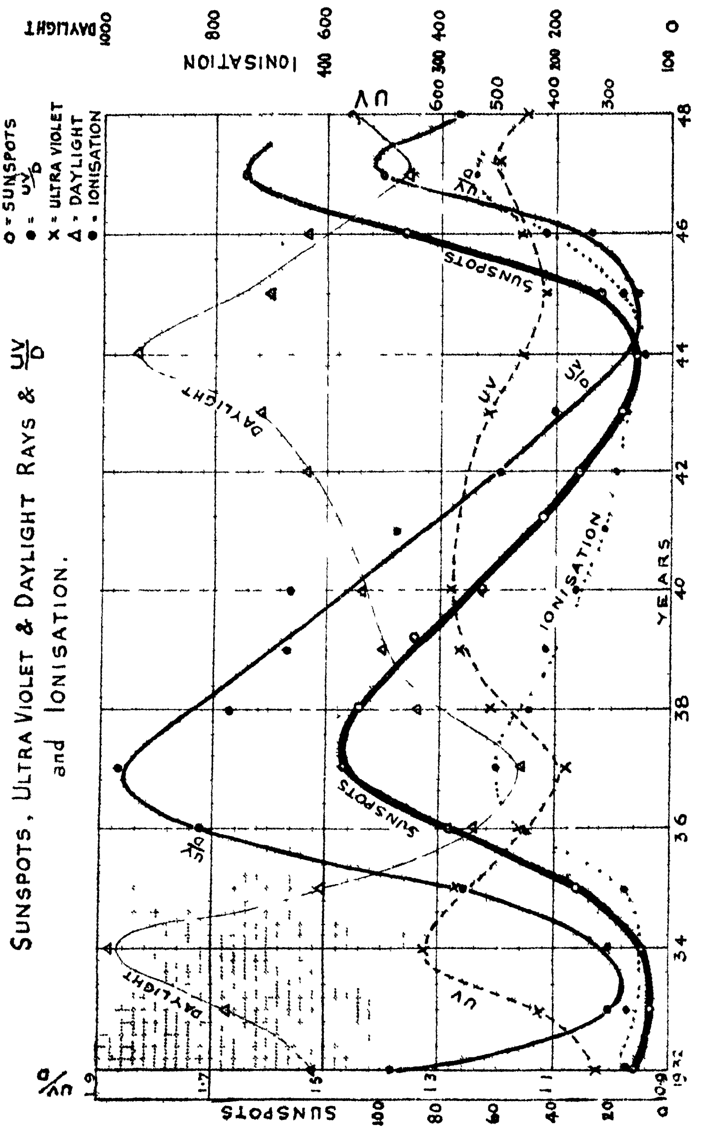
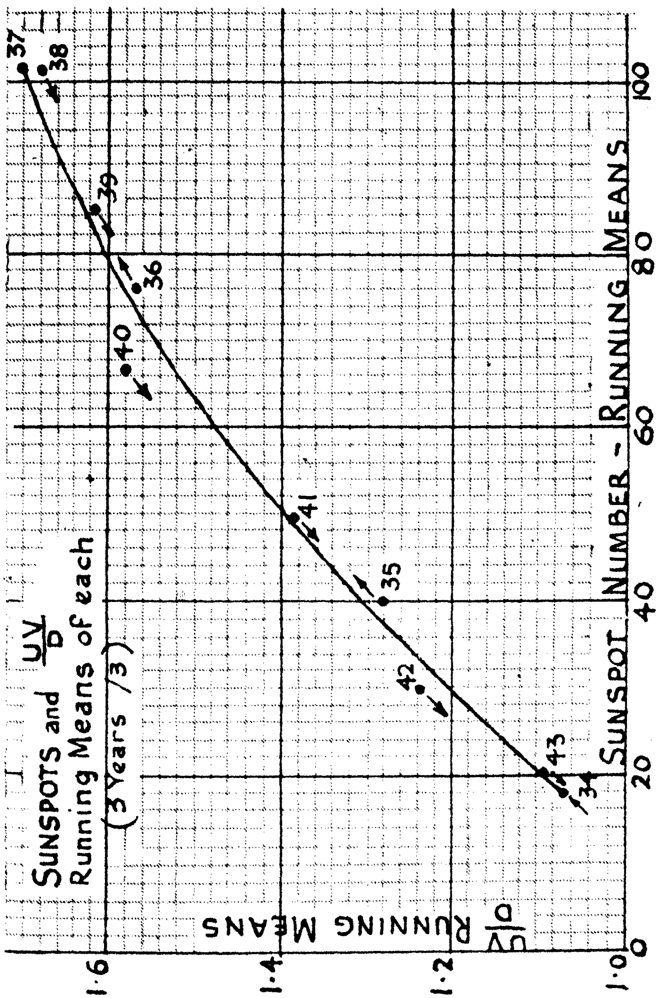

SUNSPOTS, ULTRA VIOLET & DAYLIGHT RAYS & UV/D
and IONISATION.
o = SUNSPOTS
● = UV/D
X = ULTRA VIOLET
Δ = DAYLIGHT
● = IONISATION
DAYLIGHT
IONISATION
SUNSPOTS
UV/D
YEARS
UV
DAYLIGHT
SUNSPOTS
IONISATION
1932
34
36
38
40
42
44
46
48

Fig. 1



SUNSPOTS and UV/D
Running Means of each
(3 Years /3)
UV/D RUNNING MEANS
SUNSPOT NUMBER - RUNNING MEANS
1·0
1·2
1·4
1·6
0
20
40
60
80
100
34
35
36
37
38
39
40
41
42
43

Fig. 2

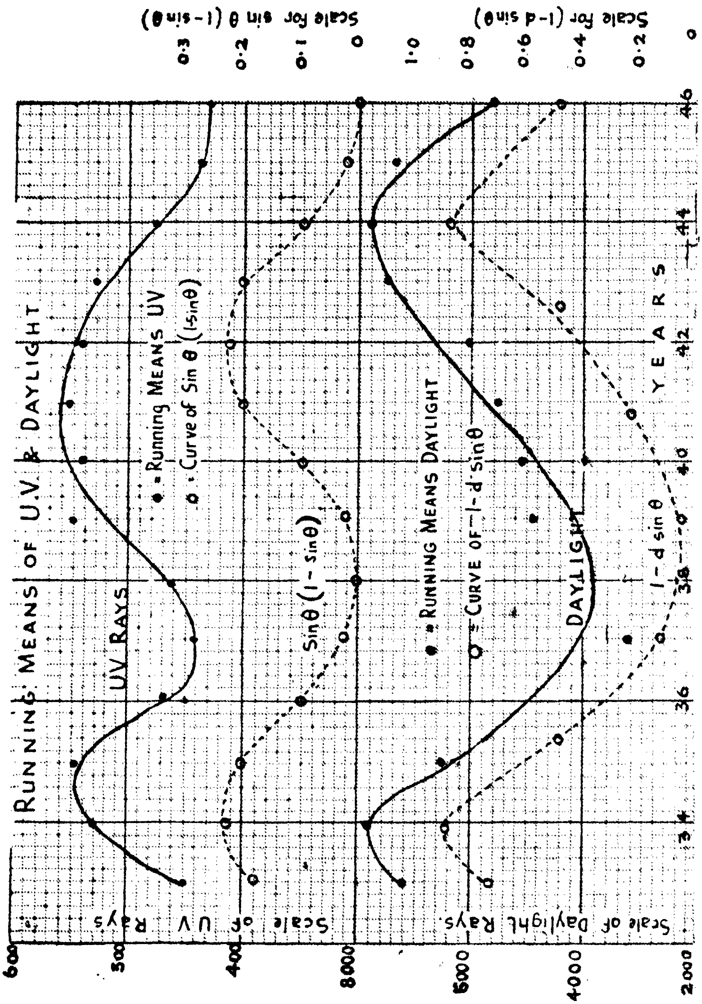
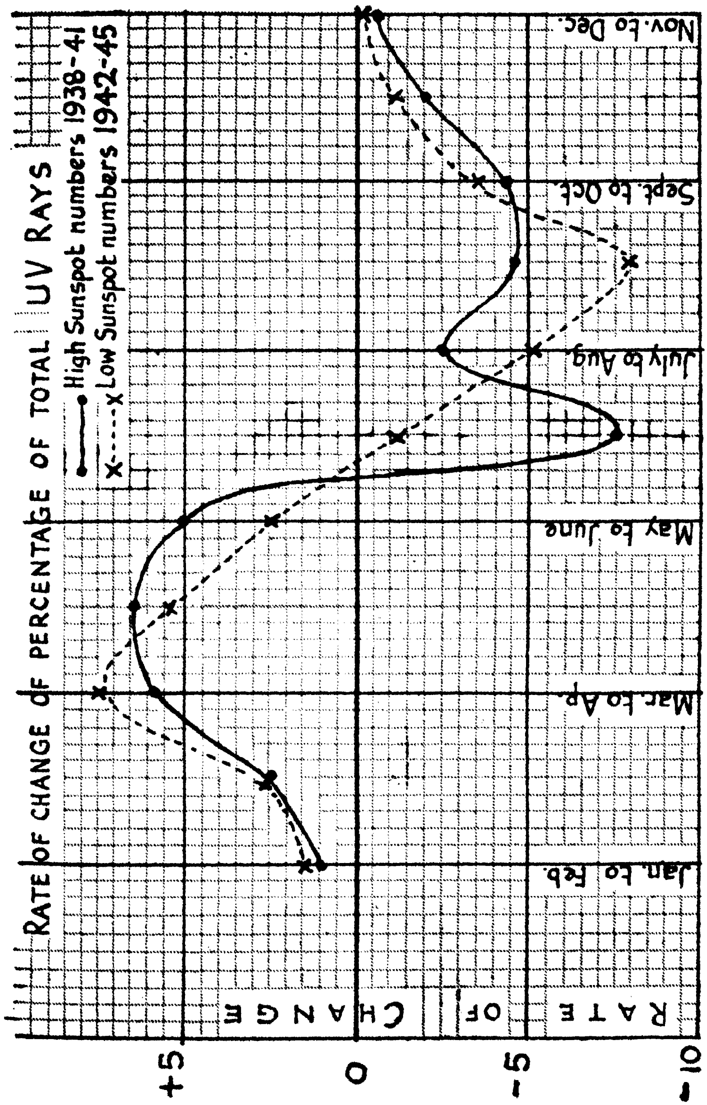

RUNNING MEANS OF U.V. & DAYLIGHT
UV RAYS
DAYLIGHT
● = Running Means UV
o = Curve of Sin θ (1-sin θ)
Sin θ (1 - sin θ)
● = Running Means Daylight
o = Curve of 1-d sin θ
1 - d sin θ
YEARS
Scale of UV Rays
Scale of Daylight Rays
Scale for sin θ (1-sin θ)
Scale for (1-d sin θ)

Fig. 3



RATE OF CHANGE OF PERCENTAGE OF TOTAL UV RAYS
High Sunspot numbers 1938-41
Low Sunspot numbers 1942-45
Jan. to Feb.
Mar. to Ap.
May to June
July to Aug.
Sept. to Oct.
Nov. to Dec.
RATE OF CHANGE
+5
0
-5
-10

Fig. 4

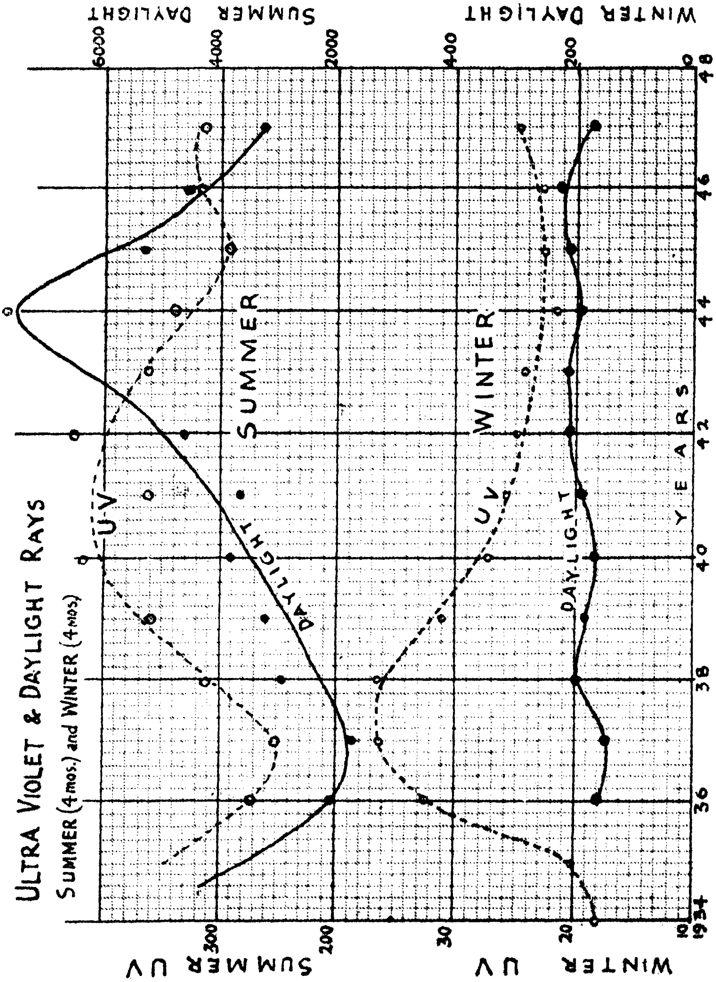

ULTRA VIOLET & DAYLIGHT RAYS
SUMMER (4 mos.) and WINTER (4 mos.)
SUMMER DAYLIGHT
WINTER DAYLIGHT
SUMMER UV
WINTER UV
6000
4000
2000
400
200
0
300
200
30
20
10
SUMMER
WINTER
U-V
UV
DAYLIGHT
DAYLIGHT
YEARS
1934
36
38
40
42
44
46
48

Fig. 5

PROCEEDINGS OF THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Session 1947–48.

Nine Ordinary Meetings were held during the session, at which lectures were delivered as follows :

1947.

Oct. 8th.	Conversazione—Whitworth Art Gallery.
Oct. 13th.	" New Anti-Malarial Drugs ", by Dr. F. L. Rose, B.Sc., Ph.D.
Nov. 3rd.	A Symposium on " Intelligence Testing in School and Work ".
Nov. 24th.	" Smoke Abatement ", by Dr. Metcalfe Brown, M.D., D.P.H. (Clayton Memorial Lecture.)
Dec. 15th.	" Three Interpretations of Greek Vases ", by Professor T. B. L. Webster, M.A., F.S.A. (President's Address.)

1948.

Jan. 26th.	" Determinism in the Physical World ", by Sir George P. Thomson, F.R.S. (Joule Memorial Lecture.)
Feb. 16th.	" National Industrial Life and the Doctor ", by Professor Lane, M.B., B.S. (Lond.), F.R.C.P. (Percival Lecture.)

PROCEEDINGS.

March 15th. " Operational Research ", by Sir Charles Goodeve, O.B.E., B.Sc., F.R.S.

April 23rd. " Applications of Mathematics to the Aeronautical Sciences ", by Professor Goldstein, F.R.S.

There were 6 meetings of the Chemical Section.

There were 10 meetings of the Social Philosophy Section.

The ANNUAL GENERAL MEETING was held on April 28th, 1948, in the Portico Library.

ANNUAL REPORT OF COUNCIL, APRIL, 1948.

Membership.

During the session 1947–48, forty-five new members were elected, ten of whom are student associate members, bringing the total up to 217 including twelve life members. There were sixteen resignations during the year.

The Council regrets to record the death of Mr. J. S. A. Salt on December 26th, 1947, an Ordinary Member of the Society.

Professor J. H. Fleure, F.R.S., was elected an Honorary Member of the Society at the Annual General Meeting on April 29th, 1947, because of his meritorious services to the Society and his eminent position in the scientific world.

Meetings.

The Annual General Meeting was held in the Council Chamber of the Manchester College of Technology on April 29th, 1947, when Professor T. B. L. Webster was re-elected President of the Society.

An Extraordinary General Meeting was duly convened and held on July 1st, 1947, for the purpose of amending Articles 66 and 67 respectively of the Society's Articles of Association.

The winter session commenced with a Social Evening at the Whitworth Gallery on October 8th. A short address was given by Mr. E. K. Waterhouse, Reader in the History of Art at the University.

The Clayton Memorial Lecture was held on November 24th, 1947, in the Reynolds Hall of the Manchester College of Technology and was given by Dr. Metcalfe Brown, M.D., D.P.H., Medical Officer of Health for Manchester, his subject being " Smoke Abatement ",

The Joule Memorial Lecture was given by Sir George P. Thomson, F.R.S., on January 26th, 1948, in the Reynolds Hall of the Manchester College of Technology who spoke on " Determinism in the Physical World ".

Dr. Thomas Percival Lecture was delivered by Professor Lane, M.B., B.S. (Lond.), F.R.C.P., at the Manchester University on February 16th. It was preceded by a tea given by invitation of the University Council to members of the Society who afterwards heard Professor Lane speak on " National Industrial Life and the Doctor ".

Details of other meetings will be found in the record of Proceedings.

Council Meetings.

Six Council Meetings were held during the session.

On behalf of the Society the Council tenders its thanks to the authorities of the University of Manchester and the Manchester College of Technology for their kindness in allowing the use of their rooms for lectures and Council Meetings.

Chemical Section.

At the request of seven members under the procedure laid down in Paragraph 89 of the Society's Articles of Association, the Council re-established the Chemical Section. Mr. E. N. Marchant, A.R.I.C., was appointed Chairman and Mr. H. Stevenson, F.R.I.C., Hon. Secretary. There have been six meetings of the Section details of which will be found in the record of Proceedings.

Social Philosophy Section.

There have been six meetings of the Section details of which will be found in the record of Proceedings. Mr. J. Coatman, C.I.E., M.A., was appointed Chairman of the Section and Mr. B. de Courcy Ireland, B.A., Hon. Secretary for the session 1947–48.

The Library.

The remains of the Society's Library, together with books and journals received since the destruction of the Society's premises at George Street are deposited in a special collection at the Central Library, Manchester. Members of the Society may consult books and journals in this special collection—other than current journals which are retained for a period in the Portico Library.

A gift of one hundred books from Yale University in memory of E. S. Harkness has been received. The Council has offered these books on loan to the Portico Library where they may be borrowed by members of the Society on application to the Portico Librarian.

Trustees.

Four members of Council have been nominated as Trustees for the handling of the Society's property.

Portico Library.

The Council wishes on behalf of the Society to express its appreciation of the co-operation of the authorities of the Portico Library which is now the registered address of the Society. Arrangements made with the Committee of the Portico Library are as follows :—

(i) Journals received by the Society are displayed in the rooms of the Portico Library for a month after their receipt. They may be consulted by members between the hours of 10 a.m. to 12-30 p.m. and 2-30 p.m. to 5 p.m. every weekday except Saturday. The Library is not open to members of the Society between 12-30 p.m. and 2-30 p.m.

(ii) A room is available for Council Meetings, Committee Meetings and Section Meetings of the Society after 3-30 p.m. The Library remains open until 7 p.m. on Wednesday evenings for the use of the Society's members.

(iii) With the exception of the books loaned by Kendal Milne & Co., or any other firm, members are allowed the use of the books in the library but are not entitled to take them away from the premises.

Assistant Secretary.

In October 1947, the Society appointed Miss Jean Armitt as Assistant Secretary who attends in the office at the Portico Library from 1-30 p.m. until 5 p.m. daily and until 7 p.m. on Wednesdays.

Chemical Society Centenary.

Mr. H. Hayhurst represented the Society at the function held to celebrate the centenary. He presented an illuminated address on behalf of the Society.

Gifts.

The Council expresses the Society's thanks to the donors of the following gifts :—

One hundred books from Yale University in memory of E. S. Harkness.

Engraving of John Dalton from Mr. Brayshaw.

A blackboard and easel from Mr. Stevenson, Hon. Secretary of the Chemical Section.

A cheque for £105 from Dr. Ashworth for the replica of the Joule portrait which he has commissioned Mrs. Hall Neal to paint.

A paper by William Sturgeon on "Some Peculiarities in the magnetism of Ferruginous Bodies," read in 1842 when he was Lecturer to the Manchester Institute of Natural and Experimental Science, is another gift from Dr. Ashworth.

Memoirs and Proceedings—Five early volumes from Mr. Guthlac Jones ; 22 volumes from Dr. Myers; 25 volumes from Professor Lang and three volumes from Mr. Andrew.

Accounts.

An audited financial statement is attached, together with particulars of assets and liabilities.

NOTE.—The Treasurer's Accounts of the Session 1947–48 have been endorsed as follows:

April, 1948, Audited and found correct.

We have seen the Banker's certificate that they hold £375 3½ % War Loan Stock: £75 Certificate No. 77/19724/7; £300 Certificate No. 82/49566. £400 3 % War Stock 1955–59: Certificate No. 41/397579. £400 3 % War Stock 1955–59: Certificate No. 41/397580. £250 3 % Defence Bonds: Bond Book No. X. 751740. £1,225 Great Western Railway Co. 5 % Consolidated Preference Stock:

£100 Certificate No. 31794.
£1,000 Certificate No. 31792.
£125 Certificate No. 31796.
NOW £1,533 10s. 11d. British Transport 3 % Guaranteed Stock 1978–88.

£7,500 Gas, Light & Coke Company Ordinary Stock: £5,500 Certificate No. 340891; £2,000 Certificate No. 347456. £100 East India Railway Company 4½ % Annuity Class A Stock: Certificate No. 25656. £700 4 % Funding Stock 1960–90: £500 Certificate No. 34185; £200 Certificate No. 23/3457. One sealed parcel marked A. One sealed parcel marked B. One sealed envelope "Papers re 21 Back George Street". One sealed envelope marked "Board of Trade Deferment Notice". One locked cash box marked "Dalton Medals, etc.".

We have verified the balances of the various accounts with the banker's pass books.

(*Signed*) G. N. BURKHARDT.

W. A. SILVESTER.

April, 1948

MANCHESTER LITERARY

H. Hayhurst, Treasurer, in Account with the

GENERAL

	£	s.	d.	£	s.	d.
To Cash in Treasurer's Hands, April 1st, 1947...				11	19	8
,, Members' Subscriptions :—						
Full Rate Arrears	43	1	0			
,, ,, 1947–48	195	6	0			
,, ,, In advance	8	8	0			
Half Rate 1947–48	0	10	6			
Student Associate Subscriptions	2	5	0			
				249	10	6
,, Life Compositions...				18	18	0
,, Dividends :—						
Great Western Railway Company's 5 % Consolidated Preference Stock... ...	33	13	8			
East India Railway Company's 4½ % Annuity Class A	4	0	3			
£300 3½ % War Stock	10	10	0			
£75 3½ % War Loan	2	12	6			
£250 Defence Bonds	7	10	0			
				58	6	5
,, Sales of Publications				27	6	7
,, Refund of Income Tax, 1946–47				28	1	4
,, Transfer from Wilde Fund				230	12	0
,, Donation				1	1	0
,, Balance due to Bankers				465	10	3
				£1,091	5	9

AND PHILOSOPHICAL SOCIETY.

Society, from April 1st, 1947, to March 31st, 1948.

FUND.

	£	s.	d.	£	s.	d.
By Balance due to Bankers...				505	17	6
,, Charges on Property :—						
Office Expenses	6	0	0			
Chief Rent (Net) and Income Tax Sch."D"	12	18	2			
				18	18	2
,, Administrative Charges :—						
State Insurance...	3	7	8			
Telephone	0	19	0			
Printing and Stationery	186	6	4			
Lecturers' Fees and Expenses...	33	5	9			
Postage and Carriage	28	9	7			
Hire of Rooms	11	9	6			
Miscellaneous Expenses	11	3	1			
				275	0	11
,, Donation to Whitworth Art Gallery				10	10	0
,, Catering at Reception				17	6	6
,, Chemical Society Centenary: Illuminated Address				13	13	0
,, Contribution towards expenses of Portico Library				184	3	4
,, Legal Expenses				8	9	4
,, Subscriptions to Societies :—						
North-Western Naturalists' Union... ...	0	14	0			
Palæontographical Society	1	1	0			
Lancashire and Cheshire Fauna Committee	0	10	6			
Royal Entomological Society	3	3	0			
,, "Nature"	4	10	0			
				9	18	6
,, Bank Charges				22	16	8
,, Cash in Treasurer's Hands				24	11	10
				£1,091	5	9

WILDE ENDOWMENT FUND, 1947–48.

	£	s.	d.		£	s.	d.
To Cash at Bank, April 1st, 1947	467	14	1	By Salary of Assistant Secretary	150	0	0
,, Dividend on £7,500 Gas Light and Coke Company's Ordinary Stock	206	5	0	,, Lecturer's Fees and Expenses	15	15	0
,, Interest on £400 3 % War Stock 1955–59	6	12	0	,, Cheque Book	0	8	4
,, Refund of Income Tax, 1944–45	174	3	0	,, Transfer to General Fund	230	12	0
				,, Cash at Bank	457	18	9
	£854	14	1		£854	14	1

BUILDING FUND, 1947–48.

	£	s.	d.		£	s.	d.
To Balance at Bank, April 1st, 1947	239	8	11	By Balance at Bank, April 1st, 1947	292	6	11
,, Interest on £700 Funding Loan 4 % Stock	28	0	0				
,, Interest on £400 3 % War Stock, 1955–59	12	0	0				
,, Bank Interest	12	18	0				
	£292	6	11		£292	6	11

JOULE MEMORIAL FUND, 1947–48. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Dividend on £100 East India Railway Company's 4½ % Annuity Class A Stock	4	0	3	By Cash transferred to General Fund	14	10	3
,, Interest on £300 3½ % War Stock	10	10	0				
	£14	10	3		£14	10	3

NATURAL HISTORY FUND, 1947–48. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Dividend on £1,225 Great Western Railway Company's 5 % Consolidated Preference Stock	33	13	8	By Cash transferred to General Fund	33	13	8
	£33	13	8		£33	13	8

SIR JOSEPH LARMOR FUND, 1947–48. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Interest on £250 Defence Bonds	7	10	0	By Cash Transferred to General Fund	7	10	0
	£7	10	0		£7	10	0

Statement relating to the Society's Property as on March 31st, 1948.

Liabilities.	£	s.	d.
Amount due to Bank on General Account	465	10	3
Liability for Volume 88 (In the press) estimate...	203	0	0

Income Tax: A claim for repayment of income tax in respect of the year 1947–48 is in course of preparation and will be forwarded to the Inland Revenue.

Loss as a result of enemy action: The claim in connection with the contents of the House and Library which was situate at George Street, Manchester, has been settled at £20,833. This amount has not been paid to the Society and no information is available with regard to the date on which payment will be made. Interest is accruing on the sum outstanding.

The claim in respect of the Society's property which was situate at 36 George Street, also 21 Back George Street, Manchester, has not been settled.

Assets.	£	s.	d.	£	s.	d.
Arrears of Subscriptions, 1947–48				10	0	0
Cash Balance :—						
In Bank, Building Fund	292	6	11			
„ „ Wilde Fund	457	18	9			
„ Treasurer's hands	24	11	10			
				774	17	6
				£785	7	6

Investments :—

£7,500 Gas Light and Coke Company's Ordinary Stock (W.E.F.) ... ...
£400 3 % War Stock, 1955—1959 (W.E.F.) ... ...
£700 4 % Funding Loan (B.F.)... ... ...
£400 3 % War Stock, 1955—1959 (B.F.) ... ...
£100 East India Railway Company's 4½ % Annuity Class A (J.M.F.) ... ...
£300 3½ % War Stock (J.M.F.)... ... ...
£1,225 Great Western Railway Company's 5 % Consolidated Preference Stock (Nat. Hist. F.) ... ...
£75 3½ % War Loan Stock, 1929–47 (G.F.) ... ...
£250 Defence Bonds (Sir J. Larmor F.) ... ...
Market Value at March 31st, 1948, £12,456.

THE WILDE LECTURES.

1897. (July 2.) "On the Nature of the Röntgen Rays." By Sir G. G. STOKES, Bart., F.R.S.

1898. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S.

1899. (Mar. 28.) "The newly-discovered Elements; and their relation to the Kinetic Theory of Gases." By Professor WILLIAM RAMSAY, F.R.S.

1900. (Feb. 13.) "The Mechanical Principles of Flight." By the Rt. Hon. LORD RAYLEIGH, F.R.S.

1901. (April 22.) "Sur la Flore du Corps Humain." By Dr. ELIE METCHNIKOFF, For. Mem.R.S.

1902. (Feb. 25.) "On the Evolution of the Mental Faculties in relation to some Fundamental Principles of Motion." By Dr. HENRY WILDE, F.R.S.

1903. (May 19.) "The Atomic Theory." By Professor F. W. CLARKE, D.Sc.

1904. (Feb. 23.) "The Evolution of Matter as revealed by the Radio-active Elements." By FREDERICK SODDY, M.A.

1905. (Feb. 28.) "The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." Dr. D. H. SCOTT, F.R.S.

1906. (March 20.) "Total Solar Eclipses." By Professor H. H. TURNER, D.Sc., F.R.S.

1907. (Feb. 18.) "The Structure of Metals." By Dr. J. A EWING, F.R.S., M.Inst.C.E.

1908. (March 3.) "On the Physical Aspect of the Atomic Theory." By Professor J. LARMOR, Sec.R.S.

1909. (Mar. 9.) "On the Influence of Moisture on Chemical Change in Gases." By Dr. H. BRERETON BAKER, F.R.S.

1910. (Mar. 22.) "Recent Contributions to Theories regarding the Internal Structure of the Earth." By Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

SPECIAL LECTURES.

1913. (Mar. 4.) "The Plant and the Soil." By A. D. HALL, M.A., F.R.S.

1914. (Mar. 18.) "Crystalline Structure as revealed by X-rays." By Professor W. H. BRAGG, M.A., F.R.S.

1915. (May 4.) "The Place of Science in History." By Professor JULIUS MACLEOD, D.Sc.

DALTON MEMORIAL LECTURES.

1931. (Mar. 17.) "Atoms and Electrons." By Sir JOSEPH J. THOMSON, O.M., D.Sc., F.R.S.

1944. (Oct. 10.) "The Atomic Theory." By Professor A. D. RITCHIE.

JOULE MEMORIAL LECTURES.

1920. (Dec. 14.) "The Work and Discoveries of Joule." By Sir DUGALD CLERK, K.B.E., D.Sc., F.R.S.

1922. (Dec. 5.) "The Rise in Motive Power and the Work of Joule." By Sir CHARLES A. PARSONS, O.M., K.C.B., M.A., D.Sc., F.R.S.

1924. (Mar. 4.) "Thermodynamics in Physiology." By A. V. HILL, O.B.E., M.A., Sc.D., F.R.S.

1928. (Mar. 20.) "Sub-Atomic Energy." By Professor A. S. EDDINGTON, M.A., D.Sc., LL.D., F.R.S.

1930. (Feb. 18.) "Science and Problems of the Times." By A. P. M. FLEMING, C.B.E., M.Sc., M.I.E.E.

1933. (Mar. 14.) "The Psychology of Musical Appreciation." By CHARLES S. MYERS, C.B.E., F.R.S.

1934. (Feb. 27.) "The Expanding Universe as a Thermodynamic System." By Professor E. A. MILNE, M.A., D.Sc., F.R.S.

1936. (Feb. 11.) "The Upper Atmosphere." By Professor E. V. APPLETON, M.A., D.Sc., LL.D., F.R.S.

1938. (Mar. 8.) "The Attainment of Low Temperatures." By Dr. C. G. DARWIN, M.C., M.A., F.R.S.

1940. (Mar. 19.) "New Applications of Physics to Medicine." By Professor JAS. CHADWICK, F.R.S.

1942. (Nov. 10.) "Man and the Weather." By Professor DAVID BRUNT, F.R.S., M.A., Sc.D.

1946. (Feb. 5.) "Atomic Energy." By Professor P. M. S. BLACKETT, F.R.S.

1948. (Jan. 26.) "Determinism in the Physical World." By Sir GEORGE P. THOMSON, F.R.S.

WILDE MEMORIAL LECTURES.

1926. (Mar. 9.) "Brains of Apes and Men." By G. ELLIOT SMITH, M.A., M.D., F.R.S.

1927. (Mar. 22.) "Physiology of Life in the High Andes." By J. BARCROFT, C.B.E., F.R.S.

1929. (Mar. 19.) "The Nature and Origin of Human Speech." By Sir RICHARD PAGET, Bart.

1932. (Mar. 15.) "Man's Place in Nature as shown by Fossils." By Sir ARTHUR SMITH-WOODWARD, LL.D., F.R.S.

1935. (Feb. 12.) "Some Sex Problems in the Fungi." By Professor Dame HELEN GWYNNE VAUGHAN, G.B.E., LL.D., D.Sc., F.L.S.

1937. (Feb. 16.) "Some Problems of the New Stone Age." By HAROLD J. E. PEAKE, M.A., F.S.A.

1939. (Mar. 14.) "Palæolithic Man in the North Midlands." By LESLIE ARMSTRONG, M.C., F.S.I., F.S.A.

1941. (Apr. 29.) "A New Era in Medicinal Treatment." By Sir HENRY H. DALE, President of the Royal Society.

1945. (Mar. 13.) "Some Antibiotics with Special Reference to Penicillin." By Sir HOWARD FLOREY, F.R.S.

1946. (Nov. 18.) "The Tides." By Professor J. PROUDMAN, F.R.S.

1948. (Nov. 15.) "Conceptions of Force in Physics." By Professor L. ROSENFELD.

CLAYTON MEMORIAL LECTURES.

1947. (Feb. 17.) "Transitions in Thought and Thought in Transition." By Professor H. J. FLEURE, F.R.S.

1947. (Nov. 24.) "Smoke Abatement." By Dr. METCALFE BROWN, M.D., D.P.H.

1949. (Mar. 14.) "The Modern Trends in Education." By Rt. Hon. R. A. BUTLER, M.A., F.R.G.S., M.P.

PERCIVAL MEMORIAL LECTURES.

1947. (Feb. 11.) "Process and Record: Aspects of Botanical Science." By Professor C. W. WARDLAW, D.Sc., F.R.S.E.

1948. (Feb. 16.) "National Industrial Life and the Doctor." By Professor R. E. LANE, F.R.C.P.

1949. (Feb. 21.) "Mechanised Trial and Error: Some Examples of Electrical Automatic Control." By Professor F. C. WILLIAMS, O.B.E.

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.

1900. Sir HENRY E. ROSCOE, F.R.S.

1903. Professor OSBORNE REYNOLDS, LL.D., F.R.S.

1919. Professor Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S.

1931. Sir JOSEPH J. THOMSON, O.M., D.Sc., F.R.S.

1942. Sir LAWRENCE BRAGG, O.B.E., M.C., F.R.S., D.Sc., M.A.

1948. Professor P. M. S. BLACKETT, F.R.S.

A detailed list of the medals, awarded to John Dalton and others, which are the property of the Society, will be found in Memoirs and Proceedings, Vol. 84, 1939–41, *pp.* xxxi—xxxiii.

A DETAILED LIST OF ARTICLES SALVAGED

FROM 36, GEORGE STREET, MANCHESTER, AFTER THE DESTRUCTION OF THE BUILDING ON DECEMBER 24TH, 1940, WILL BE FOUND IN *Memoirs and Proceedings*, VOL. 84, 1939–41, *pp.* xxxiv—xxxvii.

LIST OF PRESIDENTS OF THE SOCIETY.

Date of Election.	
1781.	PETER MAINWARING, M.D., JAMES MASSEY.
1782–1786.	JAMES MASSEY, THOMAS PERCIVAL, M.D., F.R.S.
1787–1789.	JAMES MASSEY.
1789–1804.	THOMAS PERCIVAL, M.D., F.R.S.
1805–1806.	REV. GEORGE WALKER, F.R.S.
1807–1809.	THOMAS HENRY, F.R.S.
1809.	*JOHN HULL, M.D., F.L.S.
1809–1816.	THOMAS HENRY, F.R.S.
1816–1844.	JOHN DALTON, D.C.L., F.R.S.
1844–1847.	EDWARD HOLME, M.D., F.L.S.
1848–1850.	EATON HODGKINSON, F.R.S., F.G.S.
1851–1854.	JOHN MOORE, F.L.S.
1855–1859.	SIR WILLIAM FAIRBAIRN, Bart., LL.D., F.R.S.
1860–1861.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1862–1863.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1864–1865.	ROBERT ANGUS SMITH, Ph.D., F.R.S.
1866–1867.	EDWARD SCHUNCK, Ph.D., F.R.S.
1868–1869.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1870–1871.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1872–1873.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1874–1875.	EDWARD SCHUNCK, Ph.D., F.R.S.
1876–1877.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1878–1879.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1880–1881.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1882–1883.	SIR HENRY ENFIELD ROSCOE, D.C.L., F.R.S.
1884–1885.	WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.
1886.	ROBERT DUKINFIELD DARBISHIRE, B.A., F.G.S.
1887.	BALFOUR STEWART, LL.D., F.R.S.
1888–1889.	OSBORNE REYNOLDS, LL.D., F.R.S.
1890–1891.	EDWARD SCHUNCK, Ph.D., F.R.S.

* **Elected April 28th; resigned office May 5th.**

Date of Election.	
1892–1893.	ARTHUR SCHUSTER, Ph.D., F.R.S.
1894–1896.	HENRY WILDE, D.C.L., F.R.S.
1896.	EDWARD SCHUNCK, Ph.D., F.R.S.
1897–1899.	JAMES COSMO MELVILL, M.A., F.L.S.
1899–1901.	HORACE LAMB, M.A., F.R.S.
1901–1903.	CHARLES BAILEY, M.Sc., F.L.S.
1903–1905.	W. BOYD DAWKINS, M.A., D.Sc., F.R.S.
1905–1907.	SIR WILLIAM H. BAILEY, M.I.Mech.E.
1907–1909.	HAROLD BAILY DIXON, M.A., F.R.S.
1909–1911.	FRANCIS JONES, M.Sc., F.R.S.E.
1911–1913.	F. E. WEISS, D.Sc., F.L.S.
1913–1915.	FRANCIS NICHOLSON, F.Z.S.
1915–1917.	SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.
1917–1919.	WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C.
1919.	G. ELLIOT SMITH, M.A., M.D., F.R.S.
1919–1921.	SIR HENRY A. MIERS, M.A., D.Sc., F.R.S.
1921–1923.	T. A. COWARD, M.Sc., F.Z.S., F.E.S.
1923–1925.	H. B. DIXON, C.B.E., M.A., Ph.D., M.Sc., F.R.S., F.C.S.
*1925.	REV. A. L. CORTIE, S.J., D.Sc., F.R.A.S., F.Inst.P.
1925–1927.	H. LEVINSTEIN, D.Sc., M.Sc., F.I.C.
1927–1929.	W. L. BRAGG, O.B.E., M.A., F.R.S.
1929–1931.	C. E. STROMEYER, O.B.E., M.Inst.C.E.
1931–1933.	B. MOUAT JONES, D.S.O., M.A.
1933–1935.	JOHN ALLAN, F.C.S.
1935–1937.	R. W. JAMES, M.A., B.Sc.
1937–1939.	R. H. CLAYTON, M.Sc.
1939–1940.	D. R. HARTREE, M.A., Ph.D., M.Sc., F.R.S.
1940–1944.	H. J. FLEURE, M.A., D.Sc., F.R.S.
1944-1946.	M. POLANYI, Ph.D., M.Sc., M.D., F.R.S.
1946–1948	T B. L. WEBSTER, M.A.
1948	E. J. F. JAMES, M.A., D.Phil.

* Died May 16th, 1925.

LIST OF HONORARY MEMBERS OF THE SOCIETY.

Date of Election.	
Apr. 26th, 1892.	C. LIEBERMANN.
Apr. 17th, 1894.	A. GOUY.
do.	SIDNEY VINES.
Apr. 17th, 1894.	EMIL WARBURG.
Apr. 30th, 1895.	SIR JOSEPH JOHN THOMSON, O.M.
Apr. 24th, 1900.	SIR J. ALFRED EWING.
do.	ANDREW RUSSELL FORSYTH.
do.	ROBERT RIDGEWAY.
May 13th, 1902.	SIR JOSEPH LARMOR.
do.	SIR OLIVER LODGE.
Apr. 28th, 1903.	FRANK WIGGLESWORTH CLARKE
Apr. 5th, 1910.	WALTHER NERNST.
Nov. 28th, 1922.	NIELS BOHR.
Apr. 13th, 1926.	SAMUEL ALEXANDER, O.M.
do.	ARNOLD SOMMERFELD.
Nov. 16th, 1926.	SIDNEY J. HICKSON.
do.	SIR HENRY A. MIERS.
May 13th, 1930.	F. E. WEISS.
Apr. 29th, 1947.	H. J FLEURE, M.A., D.Sc., F.R.S.

LIST OF CORRESPONDING MEMBERS OF THE SOCIETY.

Date of Election.	
Feb. 3rd, 1920.	W. S. MURPHEY.
Nov. 1st, 1921.	MRS. C. W. PALMER.
Nov. 29th, 1923.	H. F. COWARD.
Apr. 1st, 1924.	G. F. FOWLER.
Dec. 16th, 1924.	G. SENN.
Oct. 13th, 1925.	H. G. A. HICKLING.
Nov. 11th, 1941.	MISS E. OWEN.
Dec. 12th, 1944.	H. J. FLEURE.
Oct. 18th, 1948.	D. C. HENRY.
Dec. 13th, 1948.	JOHN ALLAN.
	W. H. LANG.

THE COUNCIL
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.
FOUNDED 1781.

Elected April 28th, 1948, for the Session 1948–49.

President.

E. J. F. JAMES, M.A., D.Phil.

Vice-Presidents.

M. POLANYI, M.D., Ph.D., M.Sc., F.R.S.
MISS A. C. ALEXANDER, B.Sc.
J. KENNER, D.Sc., Ph.D., F.R.S.
N. SMITH, D.Sc., F.C.S.

Hon. Secretaries.

G. F. CLAYTON.
J. G. ROGER, B.Sc., F.L.S.

Assistant Secretary.

MISS JEAN ARMITT.

Hon. Treasurer.

H. HAYHURST, F.R.I.C., A.M.I.Chem.E., F.R.E.S.

Hon. Librarians.

W. H. BRINDLEY, M.C., M.A., M.Sc., Ph.D
MISS D. EMMET, M.A.

Hon. Curator.

J. R. ASHWORTH, D.Sc.

Council.

LADY BARLOW.
Miss E. M. LIND, B.Sc., Ph.D.
M. H. A. NEWMAN, F.R.S.
R. N. SPANN, M.A.
T. B. L. WEBSTER, M.A., F.S.A.
GUTHLAC JONES.
WRIGHT GARSIDE.
NEIL PEARSON, M.B.E., M.A.
T. W. MANSON, M.A., B.Litt., D.D., F.B.A.

Chemical Section.

Chairman : E. N. MARCHANT, A.R.I.C.
Secretary : H. STEVENSON, F.R.I.C.

Social Philosophy Section.

Elected November 3rd, 1948, for the Session 1948–49.
Chairman : Professor B. A. WORTLEY.
Secretary : R. N. SPANN, M.A.

LIST OF SOCIETIES AND INSTITUTIONS

TO WHICH THE *Memoirs and Proceedings* ARE SENT.

Societies and Institutions present their publications to the Society's Library with the exception of those marked with a dagger (†).

Aberystwyth. †National Library of Wales.
Abo. Akademie Bibliotek.
Adelaide. Royal Society of South Australia. South Australian Museum. Public Library Museum and Art Gallery of South Australia.
Amsterdam. Koninkliijke Akademie van Wetenschappen. Société Mathématique. Bibliothek van het Wickundig en Genootschap.
Auckland. The Auckland Institute and Museum.
Augsburg. Der naturwissenschaftliche Verein für Schwaben.

Baltimore. John Hopkins University.
Bamberg. Naturforschende Gesellschaft.
Bangalore (Madras). Indian Institute of Science.
Basle. Naturforschende Gesellschaft. Naturforsch. Gesellsch Universitats.-Bibliothek.
Batavia. Chronica Naturae.
Berkley. University of California.
Berlin. Deutsche Akademie der Wissenschaften zu Berlin. Deutsche Geologische Landesanstalt.
Birmingham. Natural History and Philosophical Society.
Bloemfontein. National Museum.
Bonn. Naturhistorischen Verein der Rheinlande und Westfalens.
Bordeaux. Proces Verbaux des Seances de la Société des Sciences.
Boston. American Academy of Arts and Sciences.
Boulder. University of Colorado.

Brisbane. Royal Geographical Society of Australasia. Queensland Museum. Royal Society of Queensland.

Bristol. Naturalists' Society.

Brno. Faculty of Science, Masaryk University.

Brooklyn (N.Y.). Institute of Arts and Sciences.

Brussels. Institut Royal des Sciences Naturelles de Belgique. Académie Royale de Belgique. Société Belge de Géologie Paléontologie et Hydrologie.

Buckhurst Hill. Essex Field Club.

Buenos Aires. Sociedad Cientifica Argentina.

Buffalo. Society of Natural Sciences.

Calcutta. Agricultural Research Institute (Pusa). Geological Survey of India. Indian Association for the Cultivation of Science. Meteorological Department of India (Poona). Royal Asiatic Society of Bengal.

Cambridge. Philosophical Society.

Cambridge (Mass.) Harvard College. †Massachusetts Institute of Technology Library.

Canberra. National Library.

Cape Town. Royal Society of South Africa. South African Museum.

Cardiff. Naturalists' Society.

Changsa. Geological Survey of China.

Chapel Hill. Elisha Mitchell Scientific Society.

Cherbourg. Société nationale des Sciences naturelles.

Chicago. Astrophysical Journal. Field Museum of Natural History. University of Chicago Library.

Cincinnati. Lloyd Library and Museum. †American Association for the Advancement of Science. Society of Natural History.

Colorado Springs. Colorado College Coburn Library.

Columbia. University of Missouri.

Columbus. Ohio Journal of Science. Ohio State University.

Copenhagen. Kongeligt Danske Videnskabernes Selskab. Naturhistorisk Forening.

Cracow. Société Polonaise Mathématique.

Delft. Technische Hoogeschool.
Dijon. Académie des Sciences, Arts et Belles-Lettres.
Draguignan. Société d'études scientifiques et archéologiques.
Dublin. Royal Dublin Society. Royal Irish Academy.
Durban. †Corporation Museum.

Edinburgh. Botanical Society. Mathematical Society. Royal Physical Society.

Frankfurt-am-Main. Senckenbergische Naturforschende Gesellschaft.
Freiburg i. Br. Naturforschende Gesellschaft.

Geneva. Compte Rendu des Seances.
Genova. Museo Civico di Storia Naturale.
Giessen. Oberhessische Gesellschaft für Natur-und Heilkunde. (Hessen) Deutschland.
Glasgow. †University Library.
Göteborg. Göteborgs Stadtsbibliotek (Högskole).
Graz. Verein der Arzte in Steiermark.

Haarlem. Musée Teyler. Geologische Kaart. Hollandsche Maatschappy der Wetenschappen. Maatschappij-Belangen. Geologische Stichting.
Halifax, N.S. Nova Scotian Institute of Science.
Halle. Deutsche Akademie der Naturforscher.
Hartford (Conn.). Connecticut State Library (Geological and Natural History Survey).
Heidelberg. Naturhistorisch-Medizinscher, Verein zu Heidelberg.
Helsingfors. Finska Vetenskaps Societeten. Societas pro Fauna et Flora Fennica.
Hobart. Royal Society of Tasmania.
Hong Kong. Royal Observatory.

Indianapolis. Department of Geology and Natural Resources of Indiana.
Iowa City. Iowa State University. Iowa Geological Survey.
Ithaca. Cornell University. Agricultural Experimental Station.

Jassy. Bulletin de l'ecole polytechnique de Jassy, Roumania.
Johannesburg. South African Association for the Advancement of Science.

Kiel. Institut für Meereskunde der Universität Kiel.
Kyoto. College of Science, The University.

Lausanne. Société Vaudoise des Sciences Naturelles.
Lawrence. Kansas University.
Leeds. Philosophical and Literary Society. Yorkshire Geological Society.
Leeuwarden. Friesch Genootschap, van Geschied-, Oudheid -en Taalkunde.
Leiden. Maatschappig der Nederlandsch Letterkunde. Rijks Geologisch—Mineralogisch Museum. Rijks Herbarium. Société Néerlandaises de Zoologie.
Leipzig. Sachsische-Akademie der Wissenschaften.
Le Mans. Société d'Agriculture, Sciences et Arts de la Sarthe.
Liége. Société Géologique de Belgique. Société Royale des Sciences.
Lille. Société des Sciences d'Agriculture et des Arts. L'Universitaire.
Lincoln, U.S.A. Nebraska Geological Survey. University of Nebraska.
Lisbon. Observatorio Central Meteorologico. Observacões meteorologicas da Madeira.
Liverpool. Biological Society. Engineering Society. Geological Society. Hartley Botanical Laboratories. Literary and Philosophical Society.
London. British Association. British Museum (Natural History). British Museum (Library of Pure and Applied Science). British Museum Copyright Office. Chemical Society. Faraday Society. Geological Society. Institution of Civil Engineers. Institution of Electrical Engineers. Institution of Mechanical Engineers. Linnean Society. Mathematical Society. Meteorological Office. National Central Library. Patent Office. Physical Society. Quekett Microscopical Society. Royal Society. Royal Astronomical Society. Royal Geographical Society. Royal Horticultural

Society. Royal Institute of British Architects. Royal Institution of Great Britain. Royal Meteorological Society. Royal Observatory. Royal Society of Arts. †Subject Index to Periodicals. University Library. Zoological Society.

Lund. The University Library.

Luxembourg. Institut Grand Ducal de Luxembourg.

Lyon. Académie des Sciences. L'Université.

Madison. Wisconsin Academy of Sciences, Arts and Letters, Wisconsin Geological and Natural History Survey.

Madras Observatory (Kodaikanal). University.

Madrid. Academia de Ciencias. Sociedad Matemática Española.

Manchester. Association of Engineers. †Chetham's Library. †Christie Library. Conchological Society. Geographical Society. Geological Association. Microscopical Society. †Municipal College of Technology. †Central Library. Shirley Institute. Statistical Society. Textile Institute.

Manhattan. Library of Kansas State College of Agriculture and Applied Science.

Manila. Bureau of Science. Ethnological Survey.

Marseilles. Faculté des Sciences de l'Université.

Melbourne. Royal Society of Victoria.

Metz. Académie de Metz.

Mexico. Instituto Geológico. Academia Nacional de Ciencias. "Antonio Alzate."

Middleburg. Zeeuwsch Genootschap der Wetenschappen.

Milan. Osservatorio Astronomico di Merate (Como). Reale Istituto Lombardo di Scienze e Lettere. Società Italiana di Scienze Naturali, e Museo Civico.

Minneapolis. University of Minnesota. †Academy of Natural Sciences.

Missoula. University of Montana.

Montevideo. Museo de Historia Natural.

Montpellier. Académie des Sciences et Lettres.

Munich. Bayerische Akademie der Wissenschaften.

Nancy. Société des Sciences de Nancy.

Neuchâtel. Société neuchâteloise des Sciences naturelles.

New Haven (Conn.). Connecticut Academy of Arts and Sciences. Bingham Oceanographic Collection.

New York. Academy of Sciences. American Chemical Society. American Mathematical Society. American Museum of Natural History. Meteorological Observatory (Central Park). The Vanderbilt Marine Museum.

Nîmes. Académie de Nîmes.

Norman. Oklahoma Academy of Science.

Norwich. Norfolk and Norwich Naturalists' Society.

Oslo. Norske Videnskaps Akademie. Norsk Meteorologisk Institut. Observatorium. Bibliothèque de l'Université Royale de Norvège.

Ottawa. Dominion Astrophysical Observatory. Geological Survey of Canada. Royal Society of Canada.

Oxford. †Bodleian Library. Radcliffe Library.

Paris. Académie des Sciences. École nationale supérieure des Mines. École polytechnique. Muséum d'Histoire naturelle.

Peiping. Geological Society of China.

Philadelphia. Academy of Natural Sciences. American Philosophical Society. Franklin Institute. †Philadelphia Commercial Museum. Wagner Free Institute of Science.

Pietermaritzburg. †Government Geologist, Surveyor General's Office. Natal Government Museum.

La Plata. Direccion General de Estadistica de la Prov. Buenos Aires. Universidad Nacional. Facultad de Ciencias Fisico-Matematicas.

Plymouth. Plymouth Institution and Devon and Cornwall Natural History Society.

Prague. Bohmische Gesellschaft der Wissenchaft. Publications de l'observatoire national de Prague. Bulletin of the Astronomical Institutes of Czechoslovakia.

Pretoria. The University.

Rennes. Société Scientifique de Bretagne.

Rheims. Académie nationale.

La Rochelle. Société des Sciences naturelles de la Charente inférieure.

Rochdale. Literary and Scientific Society.

Rochester, N.Y. Academy of Science.
Rock Island. Augustana College Library.
Rome. Institut International d'Agriculture. Reale Accademia dei Lincei. Società Italiana per il progresso delle Scienze. Vatican Observatory (Specola Vaticana).
Rouen. Académie des Sciences.

Sacramento. See Berkeley.
St. Louis. Missouri Botanical Garden. †Academy of Science. The Washington University.
St. Paul. See Minneapolis.
Salford. †Royal Museum and Library.
San Diego. Society of Natural History.
San Francisco. California Academy of Sciences.
Santiago. Deutscher wissenschaftlicher Verein.
Seattle. University of Washington. Oceanographical Laboratories. Puget Sound Marine Biological Station.
Sendai. Tohoku Library University.
Simla. See Calcutta.
Southport. Fernley Observatory.
Stockholm. Entomologiska Föreningen. Kongeliga Svenska Vetenskaps-Akademi. Royal Library. Sveriges Geologiska Undersökning. Stockholms Högkolas Bibliotek.
Stoke-upon-Trent. North Staffordshire Field Club.
Stratford. The Essex Field Club.
Swansea. Scientific and Field Naturalists' Society.
Sydney. Australian Museum. Linnean Society of New South Wales. Royal Society of New South Wales.

Taihoku. Scientific Research Institute Ltd., National Research Council of Japan.
Toronto. University Library.
Toulouse. Académie des Sciences, Inscriptions, et Belles-Lettres.
Trondhjem. Kongelige Norske Videnskabers Selskab Museet
Troyes. Société Académique d'Agriculture de l'Aube.
Tufts, Massachusetts. Tufts College.

Uccle. L'Observatoire royale et l'Institut royal Météorologique de Belgīque.

Upsala. Kongeliga Universitet. Kongeliga Vetenskaps-Societeten.

Urbana. Illinois State Geological Survey. Illinois State Laboratory of Natural History. University of Illinois.

Utrecht. Koninklijk Nederlandsch Meteorologisch Instituut. Provincial Utrechtsch Genootschap van Kunsten en Wetenschappen.

Victoria, B.C. Dominion Astrophysical Observatory.

Vienna. Akademie der Wissenschaften in Wien. Naturhistorisches Museum.

Washington University. See St. Louis, Mo.

Washington, University of. See Seattle.

Washington, D.C. Bureau of Standards, Dept. of Commerce and Labor. Carnegie Institute. Smithsonian Institution, Bureau of Ethnology. Smithsonian Institution, United States National Museum. U.S. Coast and Geodetic Survey. U.S. Department of Agriculture. U.S. Geological Survey. U.S. Naval Observatory. †U.S. Patent Office.

Wellington, N.Z. Royal Society of New Zealand.

Wiesbaden. Nassauischer Verein für Naturkunde.

Wuppertal-Elberfeld. Naturwissenscaftlicher Verein.

Wurzburg. Physikalisch-medizinische Gesellschaft.

York. Yorkshire Philosophical Society.

Zürich. Naturforschende Gesellschaft. Schweizerischer Meteorologische Central-Anstalt.

LIST OF ORDINARY MEMBERS OF THE SOCIETY, JUNE, 1949.

Year of Election.

1928. Eric Ahlquist, The Croft, Ladybrook Road, Bramhall Park, Cheadle Hulme, Cheshire.

1920. Miss A. C. Alexander, B.Sc., c/o Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1946. Rev. Ronald Allan, The Holt House, Mobberley, Cheshire.

1942. Dr. Alexander Altmann, 38, Waterpark Road, Salford, 7.

1946. F. H. Angold, 470, Moss Lane East, Manchester, 14.

1928. G. E. Archer, M.B., Ch.B., D.L.O., F.R.C.S.(Ed.), West Thorpe, Park Road, Bowdon, Cheshire.

1945. Godfrey Armitage, 3, Didsbury Park, Manchester, 20.

1945. Mrs. G. Armitage, 3, Didsbury Park, Manchester, 20.

1943. A. Leslie Armstrong, M.C., M.Sc., F.S.I., F.S.A., 27, Victoria Road, Stockton Heath, Warrington.

1926. J. R. Ashworth, D.Sc., 55, King Street South, Rochdale.

1946. Miss E. E. Backhouse, 32, Panton Street, Cambridge.

1920. F. W. Bailey, Haven House, Broadbottom, Cheshire.

1940. Mrs. E. A. Bardsley, Alexander Hotel, Alexandra Road, Southport.

1945. Lady Barlow, Dene House, Lancaster Road, Didsbury, Manchester, 20.

1947. M. S. Bartlett, Department of Mathematics, The University, Manchester, 13.

1949. G. Bell, c/o Messrs. Tootal Broadhurst Lee Co. Ltd., Research Dept., 56, Oxford Street, Manchester, 1.

1947. A. H. Birch, 4, Windsor Road, Manchester, 19.

1948. Miss M. McLeod Black, M.A., 1, Belmore Avenue, Higher Crumpsall, Manchester, 8.

1937. Professor P. M. S. Blackett, M.A., F.R.S., The University, Manchester, 13.

1945. John Boardman, B.Com. (Lond.), 11, Parkfield Road, Cheadle Hulme, Cheshire.

Year of Election.

1949. Miss J. F. E. Bounds, " Cherfold ", Kempnough Hall Road, Worsley.

1945. W. R. Boon, B.Sc., Ph.D., F.R.I.C., 15, Gorsey Road, Wilmslow, Cheshire.

1914. Frank Bowman, M.A., M.Sc.Tech., 12, Clifton Avenue, Fallowfield, Manchester, 14.

1947. Professor A. M. Boyd, 64, Platt Lane, Manchester, 14.

1914. Major A. W. Boyd, M.C., M.A., F.R.E.S., Frandley House, Nr. Northwich, Cheshire.

1945. Miss Bozman, Manchester High School for Girls, 121, Barlow Moor Road, Manchester, 20.

1927. J. Crighton Bramwell, M.A., M.D., F.R.C.P., 15, Lorne Street, Manchester, 13.

1945. Ronald Brightman, M.Sc., A.C.G.F.C., F.R.I.C., 19, Danesway, Prestwich, Nr. Manchester.

1936. W. H. Brindley, M.C., M.A., M.Sc., Ph.D., 11, Pikes Lane, Glossop, Derbyshire.

1947. P. M. Bromley, B.A., Donner House, Oak Drive, Fallowfield, Manchester, 14.

1934. Ernest Brunner, Ph.D., Oak Tree Cottage, Castle Hill, Prestbury.

1929. H. E. Buckley, D.Sc., Bradda, Hazelhurst Road, Worsley, Lancs.

1945. R. F. I. Bunn, 169, Burton Road, West Didsbury, Manchester, 20.

1945. Miss Mabel Burdess, Edge Hill Training College, Ormskirk, Lancs.

1925. G. N. Burkhardt, M.Sc., Ph.D., F.I.C., The University, Manchester, 13.

1941. Miss A. Burton, Slethos House, 68, Sackville Street, Manchester, 1.

1920. Miss Marion Chadwick, M.Sc.Tech., 1, Didsbury Road, Stockport.

1899. D. L. Chapman, M.A., F.R.S., Jesus College, Oxford.

1943. Professor H. B. Charlton, The University, Manchester, 13.

1943. S. E. Chiotides, 29, Minshull Street, Manchester, 1.

Year of Election.

1949. O. R. Corbett, B.A., 13, Gaddum Road, Didsbury, Manchester, 20.

1946. P. Chorley, M.Sc., A.R.I.C., 32, St. Michaels Avenue, Bramhall, Cheshire.

1929. J. D. Chorlton, M.Sc., 62, Palatine Road, Withington, Manchester, 20.

1939. G. F. Clayton, 1, Parkfield Road, Didsbury, Manchester, 20.

1929. J. H. Clayton, Lymm Hall, Lymm, Cheshire.

1941. John Coatman, C.I.E., M.A., c/o The Firs, Fallowfield, Manchester, 14.

1945. Mrs. John Coatman, c/o The Firs, Fallowfield, Manchester, 14.

1945. W. Mansfield Cooper, The University, Manchester, 13.

1924. C. G. Core, M.Sc., Greystoke, Palatine Road, Manchester, 20.

1947. R. J. Cornish, M.Sc., College of Technology, Manchester, 1.

1934. Miss R. E. S. Cox, The Bungalow, Park Road, Monton, Eccles.

1916. Mrs. M. B. Craven (Life Member), M.Sc.Tech., The College of Technology, Manchester, 1.

1943. H. S. Critchley, "Three Gates," Higher Disley, Cheshire.

1945. Dr. C. J. T. Cronshaw, "Alnwick," Prestwich Park, Prestwich, Nr. Manchester.

1919. Dr. Mary Cunningham, D.Sc., 27, Clarence Terrace, Bollington, Nr. Macclesfield.

1923. George W. Cussons, The Technical Works, Lower Broughton, Salford, 7.

1929. J. A. Darbyshire, M.Sc. (Life Member), "Melandra," Kershaw Road, Failsworth, Manchester.

1946. E. Devons, 1, Darley Avenue, Manchester, 20.

1918. Miss Annie Dixon, M.Sc., F.R.M.S. (Life Member), Kauguri, Batchford Drive, St. Albans.

1947. Professor S. Dobrin, The University, Manchester, 13.

Year of Election.

1945. Professor Dorothy Emmet, M.A., 21, Yew Tree Lane, Northenden, Manchester.

1945. Dr. A. G. Evans, Chemistry Department, The University, Manchester, 13.

1946. B. S. E. Farrow, Esq., 82, Woodford Road, Bramhall, Cheshire.

1942. W. R. Fielding, M.A., M.Sc., M.Ed., Manor House, Manor Road, Fleetwood.

1924. Sir A. P. M. Fleming, C.B.E., Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

1932. Professor H. J. Fleure, M.A., D.Sc., F.R.S., 275, Church Road, London, S.E.19.

1940. R. P. Foulds, M.Sc., F.I.C., F.T.I., c/o Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1947. Wright Garside, Brereton, Ogden Road, Bramhall, Cheshire.

1922. P. Gaunt, F.R.I.C. (Life Member), Ladybarn, Letchworth, Herts.

1922. A. Gill, B.Sc., A.I.C., Hardwick, 30, Woodhill Drive, Prestwich, Nr. Manchester.

1947. Professor S. Goldstein, The University, Manchester, 13.

1947. A. H. Goulty, M.A., 7, Didsbury Park, Manchester, 20.

1947. Mrs. A. H. Goulty, M.A., 7, Didsbury Park, Manchester, 20.

1926. W. Howard Goulty (Life Member), Cornbrook, Mortimer Common, Berkshire.

1947. Herbert Gudgeon, 16, Ash Walk, Alkrington, Middleton, Lancs.

1946. W. Hagenbuch, The University, Manchester, 13.

1945. A. J. Hailwood, B.Sc., 3, Hazel Road, Altrincham.

1946. H. Hartley, 84, Macclesfield Road, Buxton, Derbyshire.

1929. Professor D. R. Hartree, M.A., Ph.D., F.R.S. (Life Member), 13, Barrow Road, Cambridge.

Year of Election.

1943. Miss M. V. Malcolm-Hayes, Mayfield, The Hough, Wilmslow, Cheshire.

1924. H. Hayhurst, F.R.I.C., A.M.I.Chem.E., F.R.E.S. (Life Member), Fouray, Parkfield Road, Didsbury, Manchester, 20.

1924. Mrs. H. Hayhurst, M.Sc. (Life Member), Fouray, Parkfield Road, Didsbury, Manchester, 20.

1948. Edgar Heald, Fernbank, Stenner Lane, Didsbury, Manchester, 20.

1948. Alexander Henderson, M.A., Economics Department, The University, Manchester, 13.

1919. D. M. Henshaw, c/o Messrs. W. C. Holmes & Co. Ltd., Engineers, Huddersfield.

1946. H. Hepworth, D.Sc., F.R.I.C., 115, Manchester Road, Wilmslow, Cheshire.

1928. J. B. M. Herbert, M.Sc., The University, Manchester, 13.

1942. Professor D. H. Hey, King's College, Strand, London, W.C.2.

1943. Alan Howard Hilton, L.D.S., 135, Great Clowes Street, Salford, 7.

1948. W. D. Hincks, Department of Entomology, Manchester Museum, The University, Manchester, 13.

1944. Samuel Hird, O.B.E., M.Sc., 12, Oaklands Avenue, Stockport.

1936. K. G. Holden, B.A., "Downshot," Alderley Edge, Cheshire.

1936. N. N. Holden, Northlea, Altrincham, Cheshire.

1943. Ernest Hollings, Dunleath, 17, Alexandra Road, Sale, Cheshire.

1944. Rev. R. V. Holt, Unitarian College, Victoria Park, Manchester, 14.

1947. J. A. Hornby, B.A., 687, Blackburn Road, Bolton.

1920. T. Horner, M.Sc.Tech., A.I.C. (Life Member), Bronwylfa, Plasuchaf Avenue, Prestatyn, North Wales.

Year of Election.

1926. O. R. Howell, B.Sc., Ph.D., Spey Lodge, 29, Palatine Road, Withington, Manchester, 20.

1945. N. S. Hubbard, Broughton Copper Works, P.O. Box 346, Manchester.

1919. Henry Humphreys, 101, Frederick Street, Oldham.

1945. B. de Courcy Ireland, B.A., 22, Alan Road, Withington, Manchester, 20.

1945. Dr. E. J. F. James, M.A., D.Phil., The Grammar School, Manchester, 14.

1945. Mrs. E. J. F. James, 143, Old Hall Lane, Fallowfield, Manchester, 14.

1923. R. W. James, B.Sc., The University, Cape Town, South Africa.

1943. Professor Geoffrey Jefferson, High Bank, Stenner Lane, Didsbury, Manchester, 20.

1943. Mrs. Jefferson, High Bank, Stenner Lane, Didsbury, Manchester, 20.

1924. Francis Jones, F.R.I.B.A., 178, Oxford Road, Manchester, 13.

1923. P. Guthlac Jones, Malista, Limefield Road, Kersal, Manchester, 7.

1948. H. F. Kearney, B.A., 16, Kenmore Road, Northenden, Manchester.

1949. A. Keller, 36, Colindale Avenue, Blackley, Manchester, 9.

1945. J. T. Kendall, M.A., Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

1928. Professor J. Kenner, D.Sc., Ph.D., F.R.S., The College of Technology, Manchester, 1.

1940. C. M. Keyworth, M.Sc., F.I.C., A.M.I.Chem.E., "Prenton," Buxton Road, Leek, Staffs.

1948. E. W. Lambert, M.A., M.Sc., A.R.I.C., F.C.S., 106, Talbot Street, Moss Side, Manchester, 16.

1931. H. S. Land, 24, Hillington Road, Ashton-on-Mersey, Cheshire.

1946. Professor R. E. Lane, 6, Linden Road, Didsbury, Manchester, 20.

Year of Election.

1917. Sir Kenneth Lee, LL.D., Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1940. H. R. Leech, The Lindens, Balmoral Road, Grappenhall, Nr. Warrington.

1948. F. N. Lees, 2, Albany Road, Victoria Park, Manchester, 14.

1948. A. G. Lehmann, M.A., D.Phil., 30, Derby Road, Manchester, 14.

1943. Miss Myee Dorothy Leigh, M.A., Lyncroft, Higher Ainsworth Road, Radcliffe, Manchester.

1931. Miss C. M. Legge, M.A., A.R.C.A., c/o Association for Moral and Social Hygiene, Livingstone House, Broadway, Westminster, London, S.W.1.

1943. Miss Margaret Lever, Lyncroft, Higher Ainsworth Road, Radcliffe.

1948. Professor W. A. Lewis, Department of Economics, The University, Manchester, 13.

1944. Dr. E. M. Lind, B.Sc., Ph.D., Ashburne Hall, Fallowfield, Manchester, 14.

1928. H. Lowery, D.Sc., Ph.D., M.Ed., F.Inst.P., F.C.P., Principal, South-West Essex Technical College, Forest Road, London, E.17.

1949. Miss M. D. McHattie, 21, Yew Tree Lane, Northenden, Manchester.

1949. W. J. M. MacKenzie, Professor of Government, The University, Manchester, 13.

1941. Rev. H. McLachlan, M.A., D.D., Litt.D., F.R.Hist.S., 11, Sydenham Avenue, Liverpool, 17.

1946. Miss A. MacLennan, 30, Errwood Road, Levenshulme, Manchester, 19.

1945. Mrs. McManus, *Manchester Guardian*, Cross Street, Manchester, 2.

1943. Miss C. E. MacWhirter, 33, Burlington Road, Withington, Manchester, 20.

1948. Miss Stella Maguire, 10, Great Cheetham Street West, Salford, 7.

Year of Election.

1947. Thomas Maguire, 10, Great Cheetham Street West, Salford, 7.

1945. Professor T. W. Manson, M.A., B.Litt., D.D., F.B.A., Woodheys, Mersey Road, Heaton Mersey, Stockport, Cheshire.

1931. E. N. Marchant, A.R.I.C., Whetherstones, Wilbraham Road, Chorlton-cum-Hardy, Manchester, 21.

1945. C. H. Marsh, Henry Simon Ltd., Cheadle, Cheshire.

1941. Dr. A. R. Martin, 30, Styal Road, Wilmslow, Cheshire.

1929. H. G. Mather, Sunnymead, Hamilton Road, Whitefield.

1949. Wolfe Mays, Dept. of Philosophy, The University, Manchester, 13.

1945. R. R. Melhuish, B.Sc., Ph.D., 10, Hill Top Avenue, Prestwich.

1939. Mrs. A. D. Melland, 17, Ladybarn Road, Fallowfield, Manchester, 14.

1939. C. H. Melland, M.D., 17, Ladybarn Road, Fallowfield, Manchester, 14.

1927. W. Melland, M.A., J.P., 1b, Cooper Street, Manchester, 2.

1936. Professor John Morley, Ch.M., F.R.C.S., The Elms, Wilmslow Road, Didsbury, Manchester, 20.

1912. J. E. Myers, O.B.E., D.Sc., The College of Technology, Manchester, 1.

1945. Professor M. H. A. Newman, F.R.S., The University, Manchester, 13.

1927. J. M. Nuttall, D.Sc., The University, Manchester, 13.

1945. Professor R. A. C. Oliver, The University, Manchester, 13.

1936. T. H. Oliver, M.D., Northern Assurance Buildings, Albert Square, Manchester, 1.

1948. J. M. Owen, Manox House, Canal Street, Miles Platting, Manchester, 10.

1946. C. Paine, B.Sc., Ellesmere, Macclesfield Road, Wilmslow, Cheshire.

1947. Ronald Peacock, M.A., Ph.D., The University, Manchester, 13.

Year of Election.

1942. David Pearson, B.A., 16, Greenbank Road, Gatley, Cheadle, Cheshire.

1946. N. G. C. Pearson, M.B.E., M.A., 1, Dickinson Street West, Manchester, 2.

1948. Miss J. K. Phillips, 6, Victoria Avenue, Didsbury, Manchester, 20.

1946. Miss D. Pilkington, Firwood, Alderley Edge, Cheshire.

1946. Sir Harry Platt, 11, Lorne Street, Manchester, 13.

1946. P. H. Plesch, A.R.I.C., M.A., Department of Chemistry, The University, Manchester, 13.

1934. Professor M. Polanyi, M.D., Ph.D., M.Sc., F.R.S., 10, Gilbert Road, Hale, Cheshire.

1945. F. R. Poskitt, Esq., Bolton School, Bolton, Lancs.

1931. Professor W. J. Pugh, O.B.E., B.A., D.Sc., F.G.S., Rathen House, Spath Road, Didsbury, Manchester, 20.

1923. Professor H. S. Raper, C.B.E., D.Sc., M.B., Ch.B., M.Sc., F.R.S., The University, Manchester, 13.

1945. William Rawlinson, Nethersyde, Wilmslow, Cheshire.

1929. Dr. W. J. Sutherland Reid, 10, St. John Street, Manchester.

1946. R. J. W. Reynolds, B.Sc., Ph.D., A.R.I.C., 13, Brierley Drive, Alkrington, Middleton, Lancs.

1920. Professor A. D. Ritchie, M.A. (Life Member), The University, Manchester, 13.

1947. F. C. Robinson, Holmdale, Hargate Drive, Hale, Cheshire.

1909. Miss Rona Robinson, M.Sc., F.I.C. (Life Member), Mosley Villa, Mitford Road, Fallowfield, Manchester, 14.

1947. Brian Rodgers, Department of Economics, The University, Manchester, 13.

1946. J. G. Roger, B.Sc., F.I.S., Manchester Museum, The University, Manchester, 13.

1947. J. D. Rose, B.A., B.Sc., 12, Orford Road, Prestwich.

1948. Professor Rosenfeld, 215, Old Hall Lane, Fallowfield, Manchester, 14.

Year of Election.

1947. Richard Rowe, Ph.D., A.R.I.C., Woodroyd, Oldfield Road, Altrincham, Cheshire.
1920. W. A. Silvester, M.Sc. (Life Member), 4, Claremont Road, Cheadle Hulme, Cheshire.
1941. A. P. Simon, Lyndale, West Didsbury, Manchester, 20.
1906. Norman Smith, D.Sc., F.C.S., 22, Broadway, Withington, Manchester, 20.
1946. R. N. Spann, M.A., 17, Brooklyn Crescent, Cheadle, Cheshire.
1926. Wm. Speight, M.Sc., The Grammar School, Manchester, 13.
1911. Miss Laura E. Start, M.Ed., Three Oaks, Marley Road, Exmouth, Devon.
1921. H. Stevenson, F.R.I.C., 31, Barchester Road, Cheadle, Cheshire.
1936. Sir John S. B. Stopford, M.D., Sc.D., F.R.S., The University, Manchester, 13.
1936. J. F. Straatman, 208, Heywood Road, Prestwich, Nr. Manchester.
1924. Stephen H. Straw, D.Sc., The University, Manchester, 13.
1924. G. A. Sutherland, M.A., Dalton Hall, Victoria Park, Manchester, 14.
1938. H. Frankland Taylor (Life Member), Innisfree, Lynne Road, Disley, Cheshire.
1945. Sir John Taylor, 12, Exchange Street, Manchester, 2.
1919. F. H. Terleski, Oakwood, Hilton Lane, Prestwich. Manchester.
1949. A. G. Thompson, Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.
1921. Professor F. C. Thompson, B.Sc., M.Sc., D.Met., The University, Manchester, 13.
1942. H. T. Thorp, " Beechwood," Pinfold Lane, Whitefield, Manchester.
1931. F. C. Toy, D.Sc., Tregays, Fletsand Road, Wilmslow, Cheshire.
1936. Miss H. L. Tuer, 8, The Garth, Yarnton, Oxford.

Year of Election.

1931. H. A. Turner, M.Sc., A.I.C. (Life Member), Ministry of Supply, Chemical Defence, Research Station, Porton, Wilts.

1947. P. F. R. Venables, Ph.D., B.Sc., F.R.I.C., Royal Technical College, Peel Park, Salford, 5.

1944. Miss Emily Verity, B.Sc., 19, Wellington Road, Fallowfield, Manchester, 14.

1921. H. Walkden (Life Member), The Raft, Derbyshire Road, Sale, Cheshire.

1944. Professor R. D. Waller, M.B.E., M.A., Extra-Mural Department, The University, Manchester, 13.

1946. Professor C. W. Wardlaw, The University, Manchester, 13.

1936. Professor T. B. L. Webster, M.A. (Life Member), Greek Dept., London University.

1942. Professor F. E. Weiss, 73, Longton Avenue, Sydenham, London, S.E.26.

1943. Frank W. Whaley, M.Sc., 126, Shaw Heath, Stockport.

1919. A. F. Williams, Kenyon Clough, Helmshore, near Manchester.

1947. D. F. Williams, 8, St. Ann's Square, Heald Green, Cheadle, Cheshire.

1946. D. G. M. Williams, 8, Lansdowne House, Wilmslow Road, Manchester, 20.

1920. J. C. Withers, Ph.D., A.R.I.C., The Shirley Institute, East Didsbury, Manchester, 20.

1945. Professor B. A. Wortley, Faculty of Law, The University, Manchester, 13.

1915. Lord Simon of Wythenshawe, "Broomcroft," Ford Lane, Didsbury, Manchester, 20.

1923. G. E. Yarrow, M.B.E., M.Sc., A.R.I.C., "Dayspring," 13, Lynton Park Road, Cheadle Hulme, Cheshire.

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HERBERT RAMSDEN

MEMOIRS AND PROCEEDINGS

OF THE

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The Modern Trends in Education

(Clayton Memorial Lecture),

By The Rt. Hon. R. A. Butler, M.P.

We are in the fifth year since the passing of the Education Act of 1944. We have had three to four years' experience of its administration. This has been a very heavy time for Committees and Directors. Now that in most cases the Development Plans envisaged under the Act have been drawn up, and the first impact of the raising of the school-leaving age has been taken and overcome, we have a chance to collect our thoughts.

Instead of devoting our attention exclusively to administration, let us consider what is being taught in the schools and what standards are being attained. Let us consider whether a national system of education can, and is, providing opportunity and whether it is able to maintain high standards.

One's first impression is that the passing of the Act has made parents take a proprietary interest in the schools, and therefore demand standards. This is one advantage of a truly national system of education.

It is difficult to examine in detail whether any other national system of education has been successful or not. Mr. Cole in his "History of Educational Thought" discusses the differing paths to culture adopted by the U.S.A. and ourselves. We have always believed in "knowledge for its own sake". The Americans have tried to provide "education through utility". 1·5 per cent. of the American population receives full time post-High-School education as compared with ·02 per cent. of our own. The older continent of Europe has tended to excel in fine workmanship, the newer continent of America in volume production. We have therefore much to learn of each other. It is chastening for us to remember that John Locke could not have adopted in his memorandum on working schools in his "Thoughts on Education" a more utilitarian attitude than he did. Locke considered the children of the poor should have a purely practical education to make them more useful. This idea persisted right up to Forster's time in the Act of 1870 which was designed to provide "a lower class usefulness".

We have made much progress between 1870 and 1944 in adapting what is taught to the age, ability and aptitude of the

pupil. Our ideal is to substitute for " lower class usefulness " a basic common culture. We have gone further and, by making religious instruction compulsory, we have attempted, like La Salle, to give our children the beginnings of a spiritual life.

Let us first consider what sort of standard is being attained in the religious instruction for which provision was made in the Education Act of 1944.

The agreed syllabuses adopted by local education authorities are very varied. They are by no means confined simply to the Bible story. They can be used effectively only by teachers who understand and agree with the doctrines and principles set out. Up till now sincerity marks the giving of religious instruction in our schools. Marked individuality of interpretation has yet to be attained.

Now to turn to a consideration of the quality of lay standards. Of course these are affected by administrative considerations. For example, keeping the elder children at school for the extra year has posed a very serious educational problem for individual teachers and schools. Let me consider first of all whether the children have profited by this extra year.

My conclusion is that a valuable and worth-while course has been provided in the most up-to-date modern secondary schools, but that the position has been impossible, or almost impossible, in all-age schools. Attempts have been made to group together children over fourteen from all-age schools and to give them special courses, but the practice has met with only limited success.

This leads me to affirm that the Education Act can never be properly interpreted until reorganisation is completed. In a reorganised modern school standards can be maintained. Last year there were still 8,014 un-reorganised schools. One-fifth of the young people over fourteen are still in un-reorganised schools.

Reorganisation has a vital effect upon Primary schools. Here we may make the second study of standards.

These deteriorate most where the size of classes is too large. There were last year 30,425 pupils in classes with over forty pupils in the primary sphere. In these circumstances a teacher

is more a circus-master than a prophet. Standards are bound to deteriorate in classes over forty.

Now to take the third test of standards which is to be found in the statistics of those taking a variety of examinations. First, 138,000 children stayed on to the age of eighteen in 1938, and 203,000 in 1948.

The number of pupils who entered for the School Certificate Examination in 1938 was 77,010 and in 1948 it was 113,192. It is interesting to note that the percentage of those who passed the certificate has remained fairly constant round about 75 per cent. during the last ten years. In the case of the Higher School Certificate the number of pupils who entered was 13,202 in 1938 and in 1948 it was 29,731. That is the number has doubled in the last ten years. The percentage of passes for the Higher Certificate has remained fairly constant round 70 per cent. Taking the purely statistical test therefore there is no doubt that more pupils are aspiring towards higher standards.

I have so far taken three tests, first in the extra year at school, second in the primary classes, and third among the pupils who take recognised examinations. What about general standards?

I would hazard an opinion after conversation with a number of H.M.I.s that in crowded schools pupils have not yet caught up the two years' backwardness which was the feature of the war period. If one were to take a pessimistic view one would say that in crowded schools pupils are still a year behind normal. In well staffed schools, with the best conditions, standards are in my view up to the level of average times of peace. Newer methods of teaching have helped where teachers are competent to carry them out.

Leaving aside general considerations let me consider the main danger which besets individual attainment of all round excellence.

This arises from undue specialisation. It has always been a feature of the English tradition that the pupil is given a general background and that the faculties are developed in the broadest possible manner. Unfortunately to-day when schools are apt

to turn themselves into factories designed to export, through narrow funnels, specialists into particularised undertakings no time is left for general study. I cannot sufficiently stress the wisdom of the words in the Report on post-war University Education published in 1944 by a Committee of the British Association.

This report suggests that the sixth-former, after devoting half his classwork and more of his private time to his speciality should " pursue four general courses, covering respectively the humanities, the social sciences, the physical sciences, and the biological sciences, affording a connected and complete, if not profound, view of the whole of civilization. English expression, a modern language, and sometimes mathematics might also be included in this programme ".

This idea has been pursued by Mr. C. R. Morris, the Vice-Chancellor of Leeds University when he says that "Our young scientists are innocent of the pleasures of Greek literature and fine Art, and our young linguists have dropped mathematics for ever at fourteen ".

I recently had the good fortune to go to Italy with a Parliamentary delegation. To live for a week in Rome is an unforgettable experience and makes one look back upon the Renaissance days when it was the ideal of the educated man to develop all sides of his mind. This surely must be the aim of the sixth form. I cannot too strongly recommend sixth-form students to study the notebooks of Leonardo da Vinci, and to note with what renounced elasticity and enjoyment he passed from one subject to another.

There is no doubt that the present examination system makes it very difficult to follow the " general " path in Education.

My happiest time at the University was when I took a year off in the middle of my studies to read a special degree in a combination of languages and science, the subjects being the " weather " and " German literature ". I remember well that I filled in intervals in this light-hearted curriculum by listening to Frazer lecturing on " The Golden Bough ", and to Bury himself talking on the " Idea of Progress ". This happy interlude was followed by a last year in which again the immense

hurdle of the Final Examination appeared before my eyes. Of course jumps and hurdles are necessary in life. There is nothing that will test stamina so completely as the Grand National course. You can be no more sure of the wind and limb of a horse which has confined its exercise to hacking on the high road than you can be sure of the characteristics of a candidate for the Civil Service, who has eaten his meals nicely and indulged in agreeable conversation at Stoke d'Abernon Manor House.

At present it is quite clear to my mind that doubts about the examination system will muddle standards. I have read very carefully the Minister's and the Vice-Chancellor of Bristol's views on the decision, thanks to which, bright pupils will be unable to take the School Certificate before they are sixteen. This in itself is wrong.

But I believe that our Prince Potentates of education will move, or may be led to move towards a sensible decision, namely that pupils should take their real examination of quality when they are seventeen. Before that age examinations there would have to be, but they might be of the " test of attainment " type based partly on internal record.

But you will never ensure standards by approaching them from the angle of the examination system. Standards can be restored only by re-establishing the one vital link in education and that is the relationship between teacher and taught. This will be achieved by a restoration of liberty of interpretation to our schools and their masters. Would that all schools were as I saw them described by Mr. Lester Smith when he spoke of the small grammar school which he attended as " a little bastion of civilization, a stronghold of freedom and liberty ".

Symposium on Juvenile Delinquency

By C. T. Cape

(Governor of Strangeways Prison).

In the year good Queen Victoria came to the throne the very first case tried that year at the Central Criminal Court in London was the case of George Doyle, who, at sixteen, was convicted of breaking into a dwelling house. It was admitted by the prosecution that he had stolen nothing. After a trial lasting only a few minutes, Doyle was found guilty, sentenced to death and duly hanged a few days later. That was just 112 years ago. At the same Sessions a few days later, Michael Roach, aged thirteen, was convicted of stealing a pair of boots valued at four shillings and six pence, and the sentence of the court was transportation for seven years.

I have seen those records for myself and also seen other prison records of similar sentences passed on prisoners of those ages. As I read about those awful sentences, I wondered what the parents of those children thought about them, and I would have liked to hear of the public opinion of those days. I look in vain to-day for some protest from the public on the passing of certain sentences.

In 1908 came the passing of the Children's Act, also known as the Children's Charter which led to the formation of a Children's Branch of the Home Office. From that time considerable progress has been made in approved schools. Although I have never had a chance of serving in approved schools I have visited them.

I have worked for eighteen years in Borstal institutions and five years in prisons, and testify to the marvellous work done in approved schools. I am glad they have nothing to do with the penal system and that they will never in any way be attached to the Prison Commission. It would be a mistake if approved schools were ever officially linked with the penal system of the country. There is a very grim and depressing atmosphere in prison but it does not exist in approved schools. The facilities for workshop training and educational advancement given there are second to none. The results, too, are most

encouraging. I am told that boys and girls leaving the approved schools with technical training seldom have difficulty in securing appointments. In the approved schools there is an atmosphere of the home, rather than of the institution and I am heartily sick of the atmosphere of institutions. Each boy or girl is treated as an individual, not in the mass. A policy of kindness and reasonable tolerance throughout the period of a boy or girl's re-education is essential.

What happens to boys and girls when they leave approved schools? I could blind you with statistics, but I will be satisfied with mentioning that four out of every five children do not get into trouble again. It is a remarkable, even a wonderful result. Children are regarded in approved schools not as pieces of rock to be chipped or putty to be moulded, but living persons to be helped and directed to live their own lives.

At Strangeways, one of my principal problems is the traditional antagonism that exists among the prisoners against the staff. It is the result of a conception that the sole duty of prison officials is to keep persons confined against their will so that the law is carried out. It is a futile thing indeed to live in an atmosphere of that kind. In the prison is a man I knew at Borstal twenty years before, and I have over and over again asked myself the question : "Where did I make a mistake with that man?" Vision and persistence are still needed in dealing with the problem of juvenile delinquency.

Symposium on Juvenile Delinquency

By J. C. Macintyre-Millar

(City of Manchester Principal Probation Officer).

An observer will notice that the same problem presents itself to-day as was met after the first world war—the effect on children of one or both parents being taken away from the home. The newspapers have been full of stories of destruction wrought by war, and children grow up in an atmosphere of uncertainty and without respect for discipline or control. The peak period of juvenile delinquency due to the war is lasting longer because the effects of the war are still gravely felt.

Again the raising of the age limit to seventeen for dealing with juveniles is responsible for an apparent increase. Personally, I do not believe children are any worst behaved to-day than they were forty years ago. The educational standards have been raised, and children have not always been provided with adequate facilities to express themselves up to these standards.

In the old days, young people were obliged to find satisfaction in the organisation of their own leisure ; to-day children expect someone else to do it for them, and this is not surprising. I do not think that Dick Barton or the cinema has anything to do with juvenile delinquency, although certain sections of the Press have tried to make out that they have been responsible for an increase. According to the Press, juvenile delinquency in Manchester has become alarming, but the fact remains that there has been no increase in the Manchester area last year. Figures for 1948 compare favourably with 1947, when there was a slight decrease on 1946. Recently a lot has been said about the damage done by children but I attribute much of it to mere devilment, and the fact that so much property is in such a dilapidated condition.

Eighty per cent. of children placed on probation, turn out satisfactorily. One interesting result of improved opportunities for further education has been the conflict which results between children of differing home background. More children are going to secondary schools and those in poorer home circumr stances are often found trying to compete with those in bette-

financial conditions. There was the case of the girl who stole a considerable amount of money by means of a trick from an old woman and spent it entertaining her school friends in a city restaurant. Blind alley jobs are another fruitful source of delinquency. Young people ultimately leave these jobs for ones which might be poorer paid and they sometimes try to make up the difference in the wrong way.

Housing is an important reason. Families herded together, and often children are made to think they are not wanted in the house. Some landlords do not want children in their houses, and parents are influenced by fear of the landlords. Consequently children are made really unhappy and then begin a movement in the wrong social direction. Manchester Corporation is tackling a tremendous job with its new housing estates. I have known families which for generations back have given to society one or two members of the criminal class. It is significant that, on the new estates, branches of the same families have produced no delinquents. Children are able to find the necessary harmless outlet for their energies.

A number of schools are in a very dilapidated state, without satisfactory playgrounds, and I hope the time will come soon when the children of Hulme and Ancoats—if they have to stay in those places—will not have to take a bus ride to a park or a meadow where they can play and enjoy freedom of movement.

Present restrictions tend to kill the initiative which is in every child. What is the probation service doing? It is dealing with broken homes.

The most important job of a probation officer is to act as conciliator. The more homes we can save, the more children will be kept away from the police courts. In Manchester last year 864 cases of conciliation were dealt with. Altogether 1,364 people came to the probation office for help and advice on 101 problems. Interviews were granted to more than 15,000 persons.

Symposium on Juvenile Delinquency

The Magistrate's View-point . . .

By Mrs. E. G. BIRLEY, J.P.

In considering this subject it is important for the general public to cultivate a sense of proportion. Juvenile Delinquency is not by any means a new problem ; nearly five thousand years ago the Sumerians complained that the young people had no respect for the law. The early Egyptians had a saying that " the ears of a boy are on his back, and he only hears when he is beaten ". Peter the Hermit in the twelfth century is said to have complained " The World is passing through troublous times, there is no reverence among our young people ; they think they know everything, moreover the girls are immodest in behaviour and in dress ".

In the Adult Courts in this country there are three chief principles to be observed, i.e.

1. The protection of the public.
2. Deterrence of evil-doers.
3. Reformation of the offenders.

Though these all apply to a certain extent in the Juvenile Court also, there the main responsibility is laid down as the " Welfare of the Child ", and re-formation of character. Over-publicity can give a very one-sided view of the problem, and it is well to remember that though there may from time to time be some startling report in the Press of juvenile depravity, yet in the whole age-group of young folk between eight and seventeen, only about 9 per cent. ever come into contact with the Courts, leaving a large number who can successfully steer their way through the difficult process of " growing-up ". For those who do get into trouble, it is all to the good that they are detected while they are still young enough to be reformed and put on the right path.

Far more boys than girls appear in these Courts, possibly showing that the parents are able to deal more easily with the girls. There is no obvious delinquent class or type, and it is not only the poorest children who get into trouble, in fact it is

really surprising how many thousands of young people living in what would be called very poor homes do lead an honest life.

Dull, possibly defective and backward children form a large proportion of the cases, and in contrast, there are the extra bright and adventurous who want to be leaders, whether for good or ill. Truancy is quite often a contributing cause, and in nearly every case what is known as a "Broken Home" is at the bottom of the trouble. There is very little evidence of any kind of moral or religious training from these parents, or interest taken in what is taught in school, besides which the discipline and general day to day standards of conduct in the home appear to vary so much that it is not surprising that the children tend to go their own way. Quite often it is found that these children have a considerable amount of "Spends" but at such irregular intervals that when they are short, there is a great temptation to obtain what they want from a gas-meter or other convenient but unlawful source.

The most difficult case of all is where the parents actually encourage their children in petty thieving, tending to warp their whole sense of right and wrong. The Cinema is frequently blamed for its bad influence, but I think unjustly; in most of the wild west type so popular with the children, the villain duly comes to a bad end, which is rightly cheered. On the other hand, the "luxury" film can have a bad effect on the young adolescent, leading to discontent with normal life, and a false sense of values.

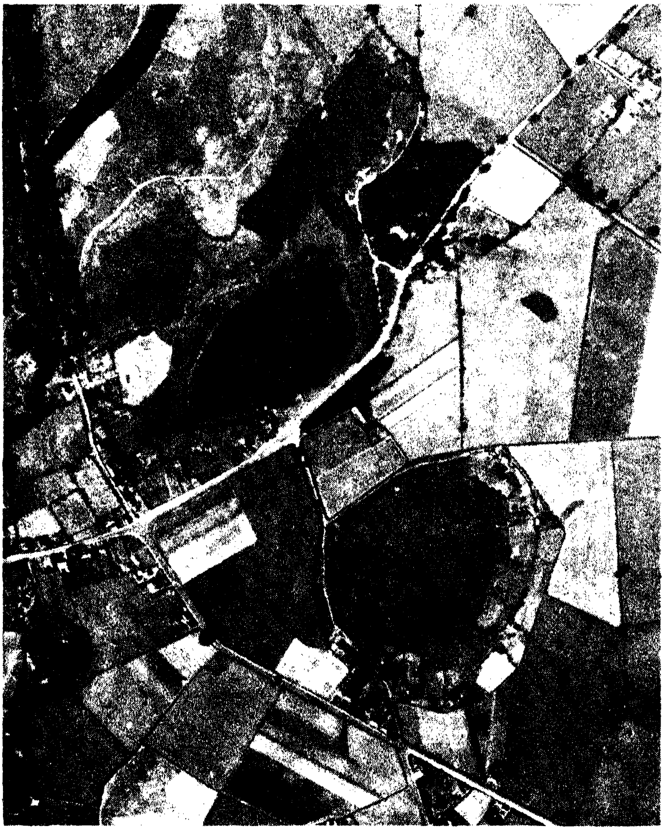
Clear and simple teaching from parents and teachers on sex and the nature of bodily functions in relation to right conduct is badly needed,—for lack of this many tragic cases are brought to our Courts, often the result of ignorance, or of part-truths picked up in a most undesirable and furtive way.

For other remedies, the first great need is better co-operation between parents, teachers and Church leaders, as at present in many cases they are working in the dark with consequent lack of success. More special classes and coaching for children who are backward, whether mentally or physically, so solving one of the chief causes of truancy; more open spaces and play-grounds

where high spirits can have their fling without danger to themselves or the general public; more opportunity to join the pre-service corps, especially Scouts and Guides, where that spirit of adventure and leadership can have its natural development, and more mixed clubs, so that boys and girls can meet together in a wholesome and natural way.

Greatest of all perhaps, is the need for better preparation for marriage and parenthood, so that the next generation may have a better chance of developing on right lines, and the supply of young delinquents be cut off at the source.

A fourth paper in this Symposium was read by Dr. Mary Burbury but was not available for publication.



Aerial photograph showing Hatchmere and Flaxmere
(*By permission of the Air Ministry*).

The History and Vegetation of some Cheshire Meres

By Edna M. Lind

Introduction.

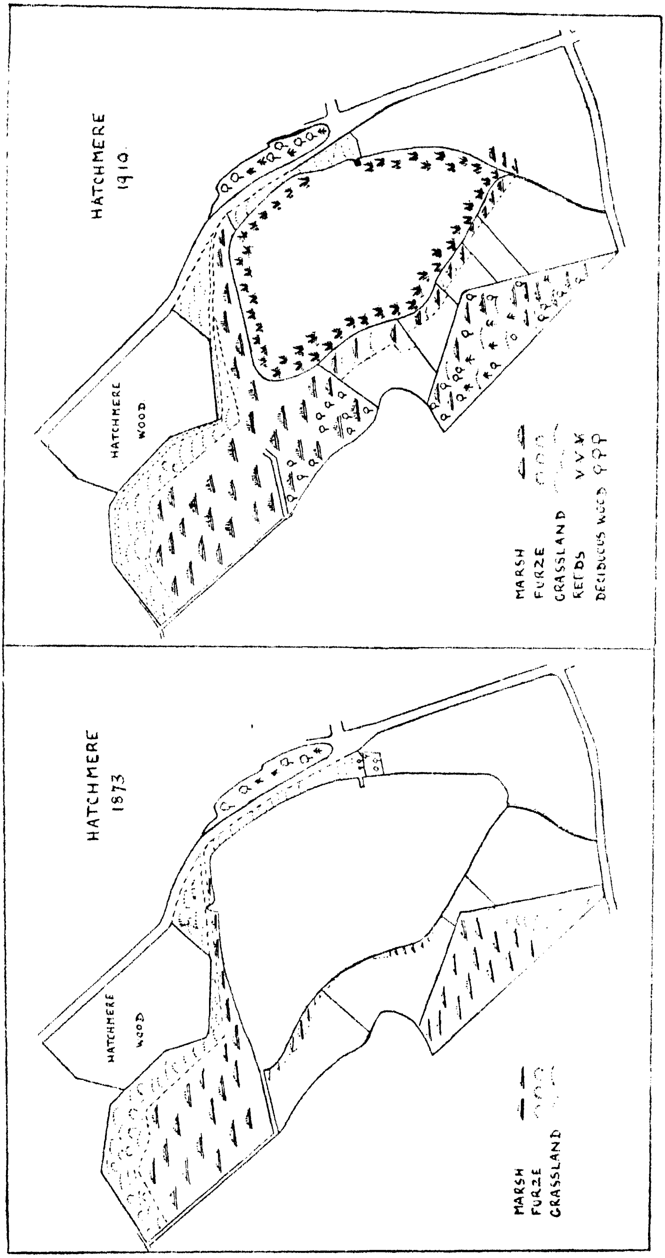
Throughout the countryside of Cheshire are scattered a large number of small lakes and pools and also many peat mosses. Many of the areas bearing the name of mere, such as Blakemere, are no longer sheets of open water but contain extensive tracts of peat moss which no doubt mark the site of former lakes; in others like Flaxmere the filling up process is still incomplete. Among the existing meres some are of the type presented by Rostherne and Redesmere with inflow and outlet and subject to heavy silting, while others like Oakmere have neither inlet nor outlet, are spring fed and have acid water. The process by which these meres may be converted into peat mosses offers an interesting study and can be seen at various stages in different parts of Cheshire.

Hatchmere affords a good example of a small lake of the silted type where terrestrial vegetation is still encroaching on the lake basin. This paper describes the plant communities round the lake shore and attempts to explain the factors underlying the succession which has taken place.

Hatchmere.

Hatchmere lies in Delamere Forest near the village of Norley, and occupies a basin in the glacial drift. The present area of water is about sixteen acres and its depth never more than sixteen feet, but there is evidence that the lake basin was formerly twice this size and is in process of filling up. Though a stream flows out at the south end, the mere is fed only by an artificial channel which collects drainage water from the surrounding fields. Two small drains flow in under the road on the east side and a large drain pipe discharges into the water near the boat house.

Reference to the Ordnance Survey maps of 1873 and 1910 (Page 18) show that significant changes in vegetation took place during these thirty-seven years, particularly in the development of reed swamp at the expense of open water and in the growth


HATCHMERE
1910
HATCHMERE
WOOD
MARSH
FURZE
GRASSLAND
REEDS
DECIDUOUS WOOD
HATCHMERE
1873
HATCHMERE
WOOD
MARSH
FURZE
GRASSLAND

of woodland. Since the 1910 survey there has been considerable further change and the map accompanying this paper records the distribution of plant communities in 1948. Unfortunately camping is allowed on the common land adjoining the mere and this has resulted in injury to the vegetation by fire, trampling and cutting of trees. It is hoped, however, that a survey at a later date may indicate the exact succession of plant communities which is taking place as the lake fills up, especially in the very wet and less frequented part near the water edge.

Description of Plant Communities.

Reference to the map will show that the water is now fringed with reed swamp which is particularly well-developed at the north-west corner. Adjacent to it is a strip of marsh which passes into willow carr abutting either on birch wood or on a large tract of *Molinia-Myrica* bog. The west shore is remarkable for the presence of *Sphagnum-Eriophorum* bog right to the water edge. There has been an attempt at fencing the land on the west bank for grazing purposes, but only the remains of the fences are left and there are no animals there now. Adjoining the west bank is a high outcrop of sandstone bearing *Calluna* and in part planted with pine trees. The south-east end is occupied by houses and cultivated land.

Aquatic Vegetation.

The lake is now under twenty feet in depth at its deepest part and in many parts much shallower. The bottom is covered with organic mud. Along the west shore is a belt of *Nuphar lutea* twenty to thirty feet wide which gives place to *Nymphæa alba* along the north shore. In the shallow water among the lilies and especially at the north end the mud is covered with *Elodea*, while *Sparganium minimum* though present with the *Elodea* is most common on the mud near the outlet end. Dunlop (Dunlop, 1910) describes great masses of *Potamogeton gramineus* washed up near the boat house after a storm. This plant still grows with *Elodea* near the boat house but none came up in the drag from other parts of the mere.

Reedswamp.

Two plants dominate the reed swamp—*Phragmites communis* and *Typha angustifolia*. *Phragmites* is most abundant at the south end and in the north-west corner where it extends through the carr and into the *Molinia* bog. It diminishes gradually along the west shore where it is replaced by *Typha*. *Typha* is found everywhere mixed with *Phragmites* and forms a continuous fringe along its lakeward edge. It is the dominant plant in the water adjacent to the *Sphagnum* bog on the west shore. Other occasional constituents of the reed swamp in the regions of more organic mud are *Eleocharis palustris*, *Carex rostrata* and *Equisetum limosum*. Associated with the reeds are a number of aquatic and marsh plants. In some parts, where the reed swamp is becoming stabilised and the mud surface is above the summer water level, it is invaded by *Sphagnum* to the exclusion of other bryophytes. Under these conditions the *Phragmites* is less dense and *Hydrocotyle vulgaris*, *Comarum palustre* and *Dryopteris spinulosa* are frequently found.

Marsh Zone.

Between the dense *Phragmites* of the inner reed swamp and the *Salix* carr is a region which may be designated marsh. The mud surface is in general above the summer water level and the vegetation is characterised by large tufts of *Carex paniculata* with *Phragmites* and a variety of fen and marsh plants. In some parts of the north shore it is this association, rather than true reed swamp which extends right up to the *Typha* fringe. It is quite firm to walk on and in it many young willows and some birches have established themselves.

Salix Carr.

The marsh vegetation passes gradually into a zone of fen with well-developed willow carr. The ground vegetation is dominated by *Carex acutiformis* with *Carex paniculata*, *Phragmites*, *Iris* and many marsh plants. The willows form a dense thicket in this very swampy area where the black mud has a *p*H of 6·07.

About ten to twelve yards inwards from the edge of the marsh *Sphagnum* species make their appearance (*S. recurvum*,

S. cymbifolium) and then *Hydrocotyle vulgaris*, *Molinia* and *Myrica* are added to the flora. Here the soil is drier, more acid (*p*H 4·49) and more highly organic than in the part dominated by the Carices. This more acid type of carr reaches right up to the original lake bank at the north end. Near the bank there are still pools with *Phragmites* and Carices but more generally the ground is drier with *Molinia*, *Myrica* and *Rubus fruticosus*. It is in the carr on the north shore that the only locality for *Cladium mariscus* is found. During the winter 1944–45 much of the wood was cut along the north-east shore where Oak, Birch, Hawthorn, Rowan and *Frangula alnus* are associated with the willows.

Alnus Carr.

This is confined to the region near the drainage channel in the north-west corner where *Alnus* replaces *Salix* as the dominant tree. *Carex acutiformis* is still the most abundant species of the ground flora but the relative absence of *Phragmites* and the presence, especially near the banks of the stream, of a rich growth of *Phalaris arundinaceæ* distinguishes it from the vegetation of the willow carr. The mud has a *p*H of 6·18 and is less organic than that of the Salix zone. *Sphagnum* has not encroached on this area.

Bog.

The north-west corner of what would appear to be the original lake basin is marked as a "turf pit" in the old maps and is occupied by a peat bog dominated by *Molinia cærula* and *Myrica gale*. The natural condition of this area has been spoiled by peat-cutting, drainage and fire so that it is now covered for the most part by dense tussocks of *Molinia* with *Myrica* scattered fairly widely and *Sphagnum*, *Menyanthes*, *Comarum*, etc. persisting in the wet depressions. In some parts, however, a typical bog community is found with *Sphagnum papillosum*, *Erica tetralix*, *Narthecium ossifraga*, *Oxycoccus quadripetala* and *Calluna*, and it is probable that if this area had not been disturbed it might have developed into a raised bog. The *Phragmites* which forms a dense reed swamp at the north-west corner of

the lake extends through the willow carr and into the *Molinia* bog where it is found quite 200 yards from the present water edge.

Where the bog is drying, especially round the edge, a woodland dominated by *Betula pubescens* with *Quercus petræa, Frangula alnus, Pyrus aucuparia* with *Salix* in the damp patches has become established and tree seedlings are plentiful all over the bog.

Two ditches, now partially overgrown, traverse the bog and have a distinct vegetation. *Menyanthes trifoliata* is abundant with *Carex rostrata, C. nigra, C. panicea,* together with *Potamegeton polygonifolius, Comarum palustre, Eriophorum angustifolium* and a number of marsh plants.

Woodland.

There is no doubt from reference to the older maps that all the present woodland is of recent development. The 1873 Ordnance Survey map shows neither willow carr nor birch wood. By 1898, brushwood has appeared on the marshy ground south of the drainage channel and deciduous woodland on the triangular peaty area, also drained, west of the south end of the lake. Even in 1910 no willows are marked ; but deciduous wood has replaced the brushwood, and conifers—planted no doubt—are growing on the triangular area. To-day there is a strip of carr along all but the west shore (where, however, there are scattered willow trees) and well-developed birch wood both north and south of the drainage channel. Stumps of old trees are seen on the triangular area where there is a new covering of birch scrub.

Though the same trees mainly *Betula pubescens, B. pendula, Quercus petræa, Frangula alnus, Sorbus aucuparia,* make up the birch wood in all parts, there is some variation in the ground flora. In the damper part to the south of the drainage channel and adjoining the alder and willow swamp *Molinia* and *Myrica* are dominant while nearer the path on slightly higher ground a more acid type of ground flora is found with rather less *Molinia* and *Myrica* but large patches of *Rubus fruticosus* and *Deschampsia flexuosa* as well as *Vaccinium*

myrtillus and other acid loving plants. In all parts, however, the presence of willow trees and pools with *Sphagnum*, and the continuous cover of *Molinia* and *Myrica* as well as the presence at a depth of five inches of *Sphagnum* peat indicates that this woodland is a recent development on original bog and that it owes its origin to the drying out of the bog consequent upon the cutting of the drainage ditch. The continuation of this process up to the present day has led to the spread of birch over the whole bog where seedlings of oak, buckthorn and also pine are not infrequent.

The West Shore. Grassland.

In the map of 1873, a considerable area along the west shore of the lake is occupied by pasture and arable land with only a narrow strip of marsh along the lake edge. The presence of fences suggests that this area was actually grazed at that time and reached to the water edge at the south end of the mere. This grassland still persists but it is now separated from the open water by a broad band of *Sphagnum* bog and a fringe of *Typha*. The position of the old fences and hedges can still be traced but the land is not grazed and is rather wet and dominated by *Juncus*, *Carex spp* and *Molinia*. Adjacent to the woodland is a slightly raised knoll with sandy soil bearing a covering of *Deschampsia flexuosa*, *Holcus mollis*, *Festuca ovina* and associated plants with patches of *Carex nigra* and *Juncus effusus* and scattered *Betula* seedlings. Passing southward, the *Deschampsia* is replaced by an almost pure stand of casepitose *Molinia* and beyond this the ground becomes wetter with *Juncus spp*, *Carex spp*, *Comarum palustre*, etc.

Sphagnum Bog.

The vegetation bordering the west side of the lake presents a striking contrast to the other shores. Opposite the edge of the birch wood, the zone which in other parts is occupied by reed swamp and carr becomes covered by a strip of bog thirty yards wide and extending about 170 yards along the shore. This area is very wet and is dominated by a dense growth of *Sphagnum*

recurvum and *Eriophorum angustifolium.* It reaches almost to the lake edge where a narrow belt of *Carex paniculata* and associated plants separates it from a fringe of pure *Typha angustifolia* with no *Phragmites.* A few willow and birch trees and an occasional pine have established themselves in the bog.

It is possible to stand on the bog quite near the water edge, and digging reveals that the *Sphagnum* cover is not deep but is a relatively recent growth covering a mass of monocotyledon leaves and shoots with *Hypnum giganteum* and other mosses. Beneath this there lies 250 cm. of sub-aquatic peat containing a few plant remains and the shells of many plankton diatoms. *Typha* persists all through the zone extending as much as twenty yards inwards from the lake and it would appear that here again we see an invasion by *Sphagnum* in recent years of an area which was formerly occupied by *Typha* reed swamp.

.Roughly opposite the end of the field now under cultivation the *Sphagnum* bog gives place again to reed swamp dominated by *Phragmites,* and *Eriophorum angustifolium* disappears. At first the reed is sparse and has much *Sphagnum* mixed with it but gradually the *Sphagnum* cover goes and is replaced by other mosses. Between here and the outlet the low ground along the lake edge is occupied by dense *Phragmites* with a band of *Carex paniculata* along the inner and outer edges and a considerable growth of *Salix* with some birch and hawthorn. There is still a fringe of *Typha* at the water edge and this plant forms a luxurious growth where the stream flows out and extends up it for about ten yards with some *Equisetum limosum.* The line of an old fence delimits this wet area near the lake from the fields on the adjacent higher land and a number of field weeds have established themselves among the reeds.

Ecological Factors influencing the plant succession.

At Hatchmere there is no evidence either now or in the past of a natural stream of any size feeding the lake, although there is drainage into the mere at several points. The outlet stream appears quite natural and it must be assumed that the lake was originally spring fed. There is evidence from the peat that the area now occupied by *Molinia-Myrica* bog represents a

former extension of the lake basin. It was, perhaps, shallower than the existing mere and filled up long ago at some fall in the water level. Our attention will, however, be mainly confined to the region surrounding the existing mere. The three plant associations—reed swamp, carr and bog, are those which are to be expected round the shores of a lake subject to silting and under fairly damp climatic conditions. Let us examine how far they here represent a natural succession and how far the development of the vegetation has been disturbed by artificial causes.

In 1873 the area of open water was considerably larger than it is now and no reeds or willows grew round the lake margin. At flood times the lake then covered the road along its east shore. Some time prior to this, however, a drainage channel had been cut round the edge of the peat bog and in the 1873 map this is shown entering the lake at its north-west corner. At some time between 1873 and 1898 when the next survey was made, a considerable drop in the water level occurred, probably due to the deepening of the outflow at the south end, and local residents affirm that the level has fallen still further in recent years. These drainage operations have had the effect of exposing round the lake margin new areas of highly organic, water-logged mud upon which vegetation has gradually established itself. The maps of 1898 and 1910 still show no willows though reeds are marked and a considerable area of " marsh " fills the north-west corner. Some notes published by G. A. Dunlop (Dunlop, 1910) describe *Potamogeton polygonifolius* extending from the soft bog into the water with *Comarum palustre* and *Menyanthes trifoliata* as typical plants of the mere margin. Of these plants the first and last are now largely confined to pools and ditches in the peat bog. By 1910 a zone of *Juncus*, *Typha* and marsh plants including *Ranunculus lingua* and *R. flammula* had been replaced in deeper water by a reed swamp dominated by *Sparganium erectum* and *Equisetum limosum* growing in soft black mud in up to six inches of water. Although it may have been present as a minor constituent of the reed swamp, there is no mention of *Phragmites* which must have reached its present abundance subsequent to 1910.

The presence of *Phragmites* round a lake shore is known to be associated with the deposition of inorganic silt which, at Hatchmere, may have resulted from the cutting of the drainage channel. There is considerable flow along this channel and it receives water charged with silt from the adjacent sandy ground and pasture land. When it was first cut the silt must have been discharged into the open water, but since the drop in the lake level much of it will have been deposited on the marshy area near the mouth of the channel. This would account for the replacement of *Sparganium* and *Typha*, plants of organic mud, by *Phragmites* in the north-west corner. The distribution of the present reed swamp bears out the view that *Phragmites* is associated with the presence of silt; for this plant is abundant not only near the mouth of the channel but near the outflow to which silt might easily be carried by currents, while *Typha angustifolia* replaces it along the east and west shores. *Sparganium ramosum* and *Equisetum limosum* both persist as occasional constituents of the reed swamp association. The mass of *Phragmites* just north of the boat house became detached and was blown across the mere some years ago from the other side.

Typha angustifolia is found in those parts of the lake most remote from silting and also forms a fringe on the lakeward edge of the *Phragmites*. Indeed, in most places the *Phragmites* zone is becoming stabilised and bears a growth of young trees and it is the *Typha* which is advancing into the open water. It may well be that silt is not now reaching the water in any quantity but is being held up by the dense reed swamp and deposited behind it. In this case the mud now collecting on the lake bottom is of a highly organic nature resulting from the decay of aquatic plants and plankton and favourable to the growth of *Typha*.

In that part of the reed swamp remote from the water where the mud surface is generally above the summer water level but is subject to flooding in winter and where the mud still has about 50 per cent. of inorganic matter, marsh plants and *Carices* dominate the ground flora and willow trees form a dense carr with *Frangula alnus* and occasional birch and rowan. In areas totally removed from the effect of silting and flooding, an acid ground vegetation dominated by *Sphagnum recurvum* and

Sphagnum cymbifolium is replacing the sedges and marsh plants while birch and oak are frequent among the willows. Here also, *Molinia* and *Myrica* are well established and it seems probable that the next stage in the succession would be the disappearance of willow with increasing acidity (many of the willows are already dead or dying) and the replacement of the carr by *Molinia* bog. The present bog occupying the old basin may have originated in this way.

One result of the partial blocking of the drainage channel by the growth of *Phragmites* on the exposed shore was the development of a *Typha* fringe. A second result is seen in the nature of the swamp on each side of the drain. This is the region of alder carr with sedges and marsh plants forming the ground flora. The *p*H of the mud here is higher than at any other part of the lake shore reaching 6·18 on the stream bank, and its inorganic content is 66 per cent. In all other parts, the carr is characterised by willow trees and is being invaded by *Sphagnum*, the mud in some parts reaching an acidity of 4·49. It would appear then that the alder and fen association owes its continuance in this region to repeated flooding by silt-bearing waters of the partially blocked drainage channel.

It is possible also, that the withholding of silt from the lake in recent years may have contributed to the increasing acidity which is evident round the shores especially on the west bank. Drainage into the lake at this side is from a high sandstone outcrop covered with a thin layer of *Calluna* peat and is no doubt highly acid. A sample taken in the *Deschampsia flexuosa* area had a *p*H of 4·15 while the acidity of the peat below the *Sphagnum* cover was 4·35. The lake water in this region has a *p*H of 6·89 compared with 7·06 off the opposite shore. The *Sphagnum-Eriophorum* bog has developed in a low-lying position at the foot of a gentle slope where it is continuously waterlogged and receives acid drainage from the surrounding land.

It would seem then that the development of vegetation round the shores of Hatchmere during the last 100 years has been a natural one following changes in the habitat. But some of the changes in the habitat have been brought about by artificial means. There seems to be no doubt that the filling up process will continue by the advance of reed swamp into the

open water followed by the development of other vegetation as the mud surface is raised above the water level. It is unlikely that this area will escape further drainage operations so the ultimate condition of the basin must remain uncertain. Further surveys, however, at intervals of about ten or fifteen years, will indicate how far the various ecological factors are still operating in the way described above.

TABLE I.

Hatchmere.

	*p*H	Percentage organic content
Phragmites	—	53·92
Phragmites (with Sphagnum) ...	5·06	62·4
Salix carr	6·07	53·3
Salix carr (with Sphagnum) ...	4·49	75·0
Alnus carr (stream bank)	6·18	43·9
Birch wood (Molinia)	3·75	82·6
Birch wood (D. flexuosa) ...	3·31	90·3
Grassland (D. flexuosa)	4·15	25·8
Bog (Molinia, Phragmites) ...	3·88	93·3
Bog (Erica tetralix, Sphagnum, papillosum, etc.)	4·18	91·7
Sphagnum bog	4·35	—
Lake water (near west shore) ...	6·89	—
Lake water (near boathouse) ...	7·06	—

*p*H estimated electrometrically.

All samples dried to constant weight at 105° C. then ignited at approximately 500° C. for 1 hour, cooled and weighed.

TABLE 2.

Hatchmere.

Frequency of species in the various zones.

	Typha reedswamp	Phragmites reedswamp	Marsh	Carr	Carr with Sphagnum	Sphagnum bog	Woodland	Ditch	Molinia bog
Phragmites communis	o	d	a	f	f	r	–	o	–
Typha angustifolia	d	f	f	–	–	f	–	–	–
Lysimachia vulgaris...	r	o	f	f	f	–	–	–	–
Epilobium palustre	r	f	o	o	–	f	–	o	–
Mentha aquatica	o	f	f	o	o	–	–	–	–
Lycopus europæus	r	o	o	–	–	–	–	–	–
Ranunculus lingua	f	r	o	–	–	–	–	–	–
Comarum palustre	f	r	f	o	o	f	–	f	–
Equisetum limosum	r	o	o	o	–	–	–	–	–
Eleocharis palustris	r	–	–	–	–	–	–	–	–
Iris pseudacorus	–	o	f	o	o	–	–	–	–
Filipendula ulmaria	–	r	f	o	o	–	–	–	–
Sparganium erectum	–	r	f	f	o	–	–	r	–
Caltha palustris	–	r	f	o	o	–	–	o	–
Heracleum spondylium	–	o	o	o	–	–	–	–	–
Angelica sylvestris	–	o	o	r	–	–	–	–	–
Valeriana officinalis	–	r	o	f	–	–	–	–	–
Lythrum salicaria	–	r	f	r	–	–	–	–	–
Galium palustre	–	f	f	f	o	–	–	–	–
Galium saxatile	–	–	–	–	–	–	f	–	–
Viola palustris	–	f	o	o	o	r	–	o	–
Scutellaria galericulata	–	o	o	–	–	–	–	–	–
Dryopteris dilatata	–	r	o	f	f	–	f	–	–
D. spinulosa	–	–	o	o	o	o	r	o	–
Athyrium filix-femina	–	–	–	–	f	–	r	–	–
Carex acutiformis	r	f	f	d	a	–	–	–	–
C. paniculata	o	o	f	o	o	–	–	–	–
C. pseudocyperus	r	r	–	–	–	–	–	–	–
C. rostrata	o	–	–	–	–	o	o	f	–
C. canescens	–	–	–	–	–	f	–	–	–
C. nigra	–	–	–	–	–	r	o	f	–
C. panicea...	–	–	–	–	–	–	–	f	–
Hydrocotyle vulgaris	–	–	o	o	o	o	–	o	–
Stellaria alsine	–	–	o	f	–	–	–	–	–
Lychnis flos-cuculi	–	–	–	–	o	–	–	r	–
Potamogeton polygonifolius ...	–	–	–	–	–	–	–	f	–

d = dominant. a = abundant. f = frequent. o = occasional. r = rare.

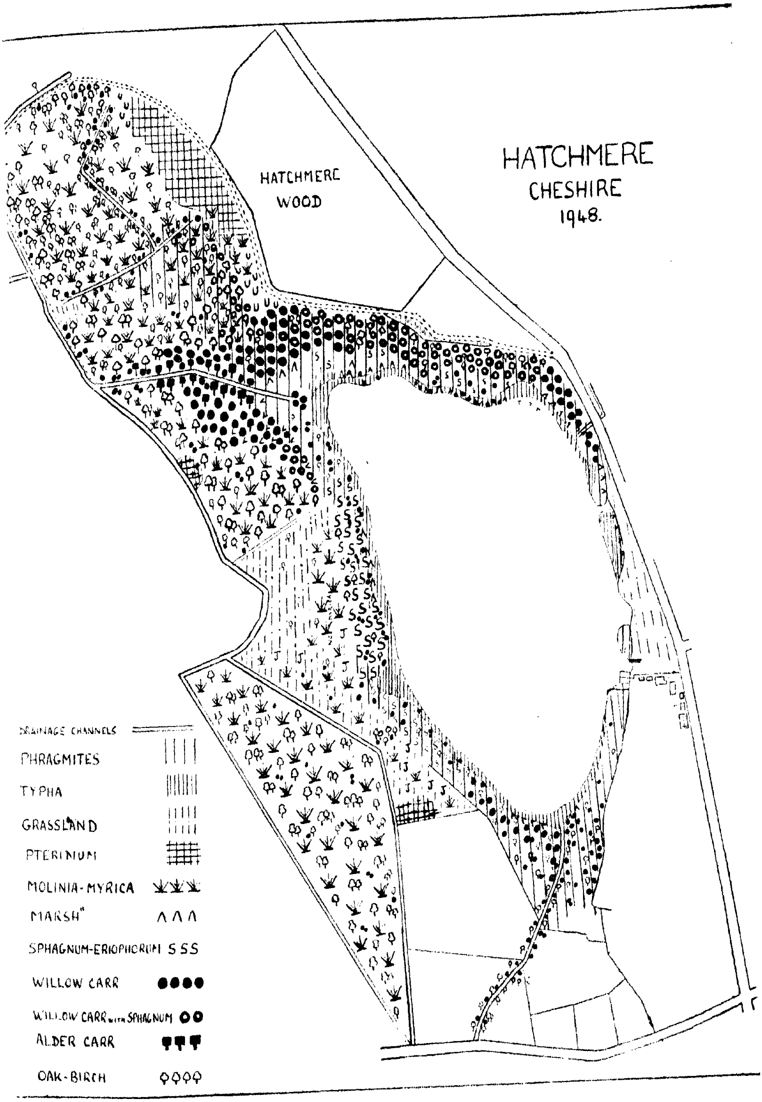
TABLE 2—*contd.*

Hatchmere.

Frequency of species in the various zones.

	Typha reedswamp	Phragmites reedswamp	Marsh	Carr	Carr with Sphagnum	Sphagnum bog	Woodland	Ditch	Molinia bog
Calamogrostis canescens ...	–	–	r	o	o	–	–	–	–
Agrostis canina	–	–	r	f	f	–	–	–	–
Deschampsia flexuosa	–	–	–	–	r	–	f	–	–
Phalaris arundinacea	–	–	–	o	–	–	–	–	–
Juncus effusus	–	–	–	–	o	r	r	f	r
Cladium mariscus	–	–	–	r	–	–	–	–	–
Cardamine flexuosa	–	–	–	f	r	–	–	–	–
Rubus fruticosus	–	–	–	r	o	–	f	–	–
Molinia caerulea	–	–	–	–	f	r	a	–	a
Myrica gale	–	–	–	–	f	–	a	–	f
Menyanthes trifoliata	–	–	–	–	–	o	–	a	o
Potentilla erecta	–	–	–	–	r	–	f	–	–
Lonicera periclymenum	–	–	–	–	r	–	f	–	–
Vaccinium myrtillus	–	–	–	–	–	–	f	–	–
Eriophorum angustifolium	r	–	–	–	–	a	–	f	r
E. vaginatum	–	–	–	–	–	o	–	–	–
Narthecium ossifraga	–	–	–	–	–	–	–	–	f
Erica tetralix	–	–	–	–	–	–	–	–	f
Oxycoccus quadripetala	–	–	–	–	–	–	–	–	f
Drosera rotundifolia	–	–	–	–	–	–	–	–	o
Sphagnum recurvum	r	r	r	–	f	d	o	f	f
S. cymbifolium	–	–	–	–	o	–	o	–	o
S. papillosum	–	–	–	–	r	r	–	–	f
S. squarrosum	–	r	–	–	r	–	–	–	–
S. fimbriatum	–	–	–	–	r	–	r	–	r
Polytrichum commune	–	–	r	o	o	f	o	–	o
Mnium hornum	–	–	–	o	o	–	o	o	–
M. affine	–	o	o	o	r	–	–	–	–
Hypnum giganteum	f	f	f	r	–	–	–	–	–
H. cupressiforme	–	–	–	–	–	–	f	–	o
Plagiothecium denticulatum ...	–	–	o	o	o	–	o	–	–
Brachythecium rutabulum ...	–	–	f	f	–	–	–	–	o
Aulacomnium palustre	–	–	–	–	–	–	–	–	o
Campylopus flexuosus	–	–	–	–	o	–	o	–	o
Lophocolea didentata	–	o	–	o	r	–	–	–	o
Marchantia polymorpha	–	o	–	–	–	–	–	–	–

d=dominant. a=abundant. f=frequent. o=occasional. r=rare


HATCHMERE
CHESHIRE
1948.
HATCHMERE
WOOD
DRAINAGE CHANNELS
PHRAGMITES
TYPHA
GRASSLAND
PTERIDIUM
MOLINIA-MYRICA
MARSH
SPHAGNUM-ERIOPHORUM SSS
WILLOW CARR
WILLOW CARR with SPHAGNUM
ALDER CARR
OAK-BIRCH

Other Meres and Pools in Delamere Forest.

These meres have not yet been studied in great detail, but as the vegetation is changing rapidly it seems wise to note their condition in 1948.

Flaxmere.

Flaxmere lies near Hatchmere on the opposite side of the main road to Frodsham. Its interest lies in the fact that this obvious lake basin is now completely filled with bog vegetation and no real open water persists. There are a number of drainage channels, particularly at the north end where the surface is relatively dry and covered with *Molinia*. There is also a deep channel at the south end by which some of the water was led off by a drain discharging into Hatchmere. In spite of this, the surface at the south end is still very wet with some small pools of open water.

The wettest parts of the bog are dominated by *Sphagnum recurvum, Sph. cuspidatum, Eriophorum angustifolium*. Where there is no standing water *Erica tetralix, Eriophorum vaginatum, Oxycoccus quadripetala, Andromeda polifolia* and *Drosera rotundifolia* come in, with *Juncus effusus* and *Polytrichum commune*, while the drier hummocks are covered with *Molinia cærulea* and *Calluna vulgaris* and *Sphagnum papillosum*. There are a few birch seedlings.

Only very preliminary investigations have been made of the peat and they show it to be over a metre in depth and composed largely of *Sphagnum-Eriophorum* peat with a thin stratum of sand in some parts at about ·5 metres. It is quite possible that following drainage of the basin, the surface was dry enough to cut for turf and a layer of blown sand may have partially covered the exposed surface. The present surface has the appearance of a renewed growth of moisture-loving peat plants under more waterlogged conditions.

Flaxmere has no natural inlet or outlet. It was probably a basin very like Blackmere containing acid, peaty water and not subject to silting. The chief agent in its filling up—as at Blackmere to-day—would be species of *Sphagnum* and some *Carices* with *Eriophorum angustifolium* and *Juncus* coming in in shallower water.

Blackmere.

This pool occupies a small basin among the trees south of the railway between Delamere and Mouldsworth. It has no inlet or natural outlet and there is now no free water surface. The whole of the centre is occupied by a mass of *Sphagnum* with *Eriophorum angustifolium, Carex rostrata* and a few clumps of rushes and is much too wet to walk on except at the edge. *Sph. cuspidatum* fills the central part with *Sph. recurvum* near the bank.

Round the edge and particularly at the western end, *Erica tetralix* and *Oxycoccus quadripetala* with *Drosera rotundifolia* have established themselves with some *Molinia* spreading from the bank, and these plants are beginning to dominate the *Sphagnum.* Twenty years ago there was a good area of open water. Some not very successful drainage has been tried and this, together with the better illumination consequent upon the felling of surrounding trees during the 1914–18 war has probably hastened the natural process of filling up. If drainage continues, or if the *Sphagnum* grows so abundantly as to present a surface which is above the permanent water-level, the invasion of *Erica* and *Oxycoccus* and more terrestrial species of *Sphagnum* will continue ; and as conditions cease to be aquatic, one would expect plants like *Molinia* and *Calluna* and eventually trees to establish themselves.

The succession which can be seen in progress at Blackmere now, has probably happened in many of the low-lying hollows in Delamere Forest. The name alone suggests that this was once a district of many meres and there still exist many boggy hollows covered with small birch and a few young pines. The whole area to the west of the road from Delamere Station to Frodsham is named Blackmere on the ordnance maps, but the pool just described seems to be the only surviving piece of really aquatic habitat.

"Sinking Pools."

"Sinking Pools" are another phenomenon of the Delamere area. The best known one was at Plovers Moss just south of the junction of the main Chester-Northwich road and the road from Norley.

This area was originally a marshy tract of forest without trees. It was subsequently planted with conifers and was well covered with trees when the 1873 ordnance survey was made. In 1897 there was a pool of four to five acres and a photograph taken in 1914 shows dead trees projecting above the water surface. It has now been drained and the area is again covered with birch brushwood though old pine stumps remain. There are a few pools with rushes and the peat surface bears *Polytrichum*, some *Dryopteris dilatata* and a little *Molinia*. The depression is not very deep and hardly looks as if it could ever have come below the natural water table. The formation of the pool was probably due to impeded drainage. More recently the same thing has happened in a part of the forest just to the east of the road from Delamere Station to Hatchmere. When Professor Newstead described this pool to Chester Natural Science Society in 1937 he said that up to five years previously there was no sign of a pool and that he and his fellow naturalists had often collected moths over the area which was then only slightly boggy. The pool is now a gloomy-looking spot with its gaunt, dead trees standing up in the quite deep water.

Oakmere.

Oakmere is a much larger lake than Hatchmere with about fifty-seven acres of water surface. It lies in a depression near the road from Winsford to Chester, not far from Little Budworth. It was formerly used as a reservoir to serve Winsford, but there has been no pumping since May, 1948.

A first glance shows this mere to be different in character from those already described, in that there is now a considerable area of exposed shore partly covered with blown sand upon which vegetation is beginning to develop. There are no reeds or bulrushes, but in their place is a fringe of rushes.

It is clear that the water level has fallen considerably in the last ten years for the boat house, which formerly stood at the water edge, is now high and dry on the bank. The fall in water level has exposed a large tract of peaty shore at the north-west end which has rapidly become covered with rushes and where willows and birches are already well established. Before the

rushes became so dense, there were old tree stumps to be seen in the exposed peat, suggesting that this area had once been terrestrial, subsequently becoming submerged and now once again exposed. Pieces of peat from this north end become detached and are blown down the lake, but the bed of the mere under the water in other parts appears to consist of shingle and sand.

Oakmere has now neither inlet nor outlet though apparently it formerly had a small outlet at the north-west end, which was dammed when the lake became a reservoir. When 12,000 gallons a day were being pumped the water level quickly re-adjusted itself, presumably from springs and drainage, and now that pumping is suspended it remains at what would appear to be the level of the permanent water table in this area. If this is so the permanent water level has fallen in recent years and the present shore will remain exposed and quickly cover itself with vegetation.

Oakmere, having no inlet, is not subject to silting. The upper, drier part of the shore has a good covering of mosses, largely *Polytrichum commune*, with scattered plants of *Calluna*, *Molinia*, *Erica tetralix* and *Juncus effusus* and many young birch trees. There is a distinct drop in level as one passes from this drier zone to a wetter one with abundant mosses, more rushes, less birch and *Drosera rotundifolia* on the bare peat. Between this and the water edge at the peaty end, is a very wet zone with abundant rushes, *Hydrocotyle*, *Sphagnum* and aquatic mosses. The *Hydrocotyle* spreads right into the water where it is joined by *Juncus bulbosus*. Scattered over all zones are seedlings of birch, pine, willow and rowan.

In 1935, when the water level was very low, a keeled dug-out canoe was found half-buried in the shore. Mr. Rock, the keeper, noticed the prow of the canoe exposed about the level of the mere. It was carefully excavated and found to be resting on a bed of gravel and silt and covered with sand interstratified with peat. (Newstead.)

In 1940 two bombs fell in the wood near Mr. Rock's house. This made a considerable disturbance in the underlying sand layers and water escaped from the mere causing a further slight drop in the level.

The water at Oakmere is much more acid than that of Hatchmere, sometimes reaching *p*H 4·5 and it has a peculiar phytoplankton of which the oil-forming alga, *Botryococcus*, is the most common component.

The evidence so far suggests that Oakmere also fills a basin in the glacial sands which drops below the permanent water table. It is spring fed and has long been subject to fluctuations in water level. During a previous period of low water, vegetation formed peat in the shallow bays. This peat was later submerged and is now exposed and being recolonised.

[This work was carried out from the Department of Botany, Manchester University, to whose members the author expresses her thanks for help in the field.]

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The Manorial Mills of Manchester
1525 to 1883

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The manuscripts in the possession of the Manchester Grammar School contribute a little towards the history of Manchester because the school endowments made feoffees responsible for the administration of the manorial mills, a service which concerned all the burgesses.

The foundation deed of the school is primarily a transference of property from the founder to his trustees or feoffees, so that they might carry out his wishes. So the 1525 deed begins: "Whereas one Thomas Weste, Knight, Lord la Warr, did grant, (to Hugh Oldham) all his lands and tenements, rents, and services of his water corn mills, called Manchester Mills, upon the rivulet of Irke ; and also all the tolls soken of the aforesaid mills of all the tenants of the said Lord la Warr ; and further, his fulling mill, called a Walke Mill situate upon the rivulet called Irke ; and also his close of land called Walker's Croft ; and also the rivulet of Irke and the free fishery of the same, from Asshelle Lawn, as far as the river called Irwell ; and full power and authority and right of making, setting up, fixing, and attaching mills, and so many and such weirs, floodgates, and fastenings to both sides of the same rivulet, called Irke, and upon, through, and across the same water, in any places whatsoever, from the said Asshelle Lawn unto the said river of Irwell ".

These mills are described first in the 1262 survey of the manor. "There is in the aforesaid manor one watermill" (a second had been built by 1525) "which is worth yearly £17. 6s. 8d. and a certain fulling mill which is worth yearly 26s. 8d.". And in the charter of 1301 from the lord of the manor to his burgesses it says: " the burgesses shall follow, that is do suit at, the mill of the lord, paying to the mill the customs as they ought and are wont to do ". This was the property which Hugh Oldham bought from the lord of the manor, Lord la Warr, to provide an income for the school. The portion of the Irke mentioned has been covered over by the road called Walker's Croft, running along beside Chetham's Hospital, and then by Victoria Station. The two corn mills were on the left bank going down stream ;

the higher mill was called the Town's Mill, the lower the School's Mill. Between them on the other bank was the fulling or Walke mill, a gigantic washing machine for cleansing grey cloth. When cleaned the cloth was stretched on frames to bleach in the open air, on the croft behind the mill.

The remarkable thing about this endowment was that the feoffees of the school were made responsible for two public services, a free school and the management of the mills which ground the corn and malt for Manchester. In the earliest times the Manchester villeins grew their own rye or maslin for bread, and barley for malt. Later the burgesses bought their grain from local farmers in the market. But the housewife still had to send it to be ground at the manorial mills, for the flour dealer and the brewer had not yet appeared, and bread and beer were made at home. In payment for grinding, the miller took one twenty-fourth of each sack of grain. In the early inventory of each mill there is mention of the toll ark, the bin in which the corn so taken was stored. The mills were farmed out at a yearly rent; the farmers were considerable men of the district, land-owners, merchants, and lawyers. In their turn, they employed millers who lived at the mills. The inventory includes "a bedstead, flock bed, bolster, two blankets and coverlet, two feather pillows, and a pair of sheets".

This was the system inherited by the feoffees, but their responsibility was not ended when they had found a tenant for the mills, for they were responsible for seeing that the monopoly was not infringed, and that no harm was done to the water power which drove the mills. Thus they were let in for four centuries of litigation. The word monopoly had an ugly sound in nineteenth century Manchester, which forgot that it was one aspect of a public service; for if all were bound to send their grain to the school mills, yet the mills were bound to grind all that was brought to them. If they could not there was risk of a shortage. That might happen in time of flood or drought. In flood the water wheels might fail to revolve because of back-water; that is, the raising of the height of the stream so that the lower part of the wheel was submerged. Or else the wooden wheels might be smashed and even the weirs carried away.

Repairs took time. In drought there was too little water to turn the wheels, and nothing could be done about it. When the delay in grinding exceeded twenty-four hours the burgesses might take their grain to other mills. These abounded ; in the eighteenth century there were sixty on the Irk alone. The danger was that other mills sought to attract customers by lessening their toll. To take advantage of these cut prices, Manchester tenants would find every excuse for complaint against their own mills. If there were no flood or drought, then it was that the miller took more toll than he should. That was often true ; millers were notorious for their sleight of hand. If the monopoly were evaded the farmer would ask compensation by a reduction in rent ; it would be more difficult to get a good rent in future. More serious still, it was very difficult indeed to get legal recognition of a monopoly which had been persistently evaded, without the owners attempting to prevent it. So the feoffees were concerned to see that no one took his grain elsewhere, and that the tenant did not give needless cause for complaint. A weighing machine was kept in each grain mill, so that customers might detect fraud. Horses were employed to fetch and carry the grain from each house. This was not obligatory but it was a service which made people less liable to take their grain elsewhere. The inventory mentions several loads of hay, and a white and a bay mare ; they were pastured in the fields at Ancoats which Oldham had included in his endowment.

When evasion was flagrant the authority of the manorial court was invoked. At a meeting of the court held on April 11th, 1577, " the Jurye did presente yt whereas Dyvze (divers) orders heretofore made to thend the Inhabitants of the towne shoulde grynde their greyne and cornes at ye Lords mylnes, Notwithstandinge many not regarding theire comon wealthe and good educatyon of theire children in ye said schoole (of Manchester) willfullye absente themselves and grynde at other myllnes now to the greate hinderance and in short tyme yf not pryded for, to the greate overthrowe of the saide schoole, which only ys founded and maynteyned by suche comoditye, as doth grow by the same, these therefore are to desyre all those yt doe absente themselves from the said Myllnes, yt they woulde bringe or cause to be broughte theire corne unto the same myllnes there

to be grounde . . . and yf gentle request will not serve, then to thincke no uncurtesye, yf we use suche meanes, as we maye lawfully may, to compell them to the same". If the manor court could not enforce the monopoly, appeal had to be made to the Court of the Duchy of Lancaster.

It was also necessary to preserve the water power by which the mills worked. The mills themselves were no more than thatched wooden sheds, covering the gears which transferred the vertical movement of the water wheel to the horizontal movement of the mill stones. They wore out and were replaced every ten or twenty years. But the water power that drove the mill wheels was the real treasure of the property. If that failed, all was lost. The law recognised this. For instance in 1792 a bill was presented to parliament to allow the building of a canal to link the Calder canal at Halifax with the Bridgewater canal. As first planned, it would have tapped two small streams, Trub Smithy Brook and Springs Brooks, which wandered down the moors beyond Rochdale to feed the Irk. The feoffees opposed the bill and petitioned both the houses of Parliament and the two universities. Their case was that any decrease in the flow of water into the Irk would prevent them from complying with their obligation to grind for Manchester, and rob them of the income which maintained the school. "This school has flourished for Ages past—and as it is free to the whole British Empire, Youth from all Parts thereof have received its Advantages—and great Numbers now resort thereto. Its Income not only affords the Means of Instruction to Youth at the school, but also promotes the Advancement of Knowledge and Learning by further assisting them in their Education at Oxford and Cambridge". The promoters of the canal were obliged to modify their plans, build reservoirs to feed their canal, and culverts to take the feeders of the Irk safely under it. This they hoped would disarm opposition. "In this high and hilly country, many parts of which lie more than one thousand feet above the level of the sea, and in which the rains are not only frequent, but violent, these reservoirs will be filled many times annually, although when filled only *once*, their content will be more than sufficient for the supply of water to the canal for the *whole year*". In addition they pleaded that the passing of thirty boats a day

along the canal would cause an overflow which would ultimately benefit the Irk. In the end they offered to lease the school mills for £100 a year more than the average profits from them of the last seven years. The offer was refused, and the feoffees succeeded in ensuring the rejection of the Act for the Rochdale canal in the parliamentary session of 1793.

Below the school mills the chief danger was in any alteration of the height of water in the Irwell. The power of the water which turned the mill wheels was due to its fall over the three weirs between the upper and the lower mill. If the level of the water in the Irwell were raised it would decrease the amount of the fall, and so put the lowest wheel into backwater. In 1721 the Mersey-Irwell Navigation Company was formed to deepen the river system between Liverpool and Manchester. But the feoffees prevented their operations extending as far along the Irwell as it was intended, since they would have raised the level of the river. At the end of the century the feoffees thought of abandoning the lower mill and utilising the centre mill, once the Walke mill, for malt grinding. Whereupon the Navigation Company offered to pay a substantial sum to allow them to make the Irwell navigable up to its confluence with the Irk. A millwright from Halifax, called John Sutcliffe, was consulted, and gave this report in January, 1795.

"If the trustees begin to dismember the estate they will ruin the remainder of it. The School Mills taken collectively are like a well-constructed arch, where every stone has a mutual dependence upon each other ; but if one is displaced the whole must tumble down together. If the lowermost mill was sold to the Proprietors of the Old River below it, to give them navigating depth, as high at least as the top of the weir that conducts the water to it, and the consequence of this would be that any time there was a fresh in the river, the centre mill would be put into backwater and then it would be rendered incapable of grinding the malt for the town ; and I am inclined to think that this would liberate the Town from grinding malt at that mill. The central mill I consider as the Pillar of the School estate, and great care ought to be taken that nothing be done to injure it. The lowermost mill is a kind of guardian to the central mill in preserving it from backwater ; but if ever

the lowermost mill is destroyed, from that moment the fate of the central mill will be sealed and its destruction certain so far as it respects grinding Malt for the town of Manchester."

This double responsibility attached to the care of the endowment of preserving its value for the school and maintaining its service for the town is recognised in the 1525 statutes, by two provisions. The first is for the office of a receiver, described as "a substantial person dwelling within the parish of Manchester, which shall receive the rents and profits of all the whole lands concerning the school, which receiver shall make his accompts for the receipt, and for all necessary reparations and payments done there, once in the year in Manchester, before the warden of the college, two of the feoffees, and the high master, to make a true accompt of everything, and true allowance ask upon his oath, and bring and deliver yearly the surplusage above all wages, reparations, and such other necessary expenses". Secondly, particular permission is given to pay out of surplus funds "all charges in the law for the defence of the lands of the school".

The earliest records of the administration of the school property date from the seventeenth century. They are a number of rough notes, accounts, and letters of John Hartley of Strangeways, who farmed the mills from 1647 to 1660.

The Civil Wars had dislocated the administration of the school. The High Master, Brideoak, was a Royalist who left Manchester to serve the Derby family. By 1647 the number of feoffees had sunk by death to three, and they were Royalist. So Parliamentarian Manchester petitioned Parliament to appoint new feoffees, since "many of the feoffees are dead or delinquent so that for lack of direction the school and its revenues are neglected". This was done, although it was illegal according to the deed of 1525. The new feoffees appointed a new High Master John Wickens, deprived the Royalist Thomas Prestwich of his tenancy of the school mills and leased them to John Hartley, a draper or clothier, one of the most considerable men in Manchester, a contemporary and trustee of Humphrey Chetham. He lived in Strangeways Hall, and his estate map of 1641 shows his property bordering on that of the school. A stream running

by the hall turned a fulling mill, and on the banks of the Irwell Hartley had two yarn crofts; so that the school's Walke mill and croft were of use to his textile business.

John Hartley was succeeded by his son-in-law, also called John Hartley. The latter spent a great deal of money in reconditioning the mills and in enforcing the monopoly, only to lose his tenancy at the Restoration in 1660 when the legality of the appointment of feoffees by Parliament during the Commonwealth was challenged. To substantiate his claim to compensation Hartley wrote out the lists which still exist, of costs of materials and labour for rebuilding the mills. For the Walke Mill there is mention of two loads of tenter bars and 7,400 tenterhooks.* The mill cost him 256 days labour at sixpence a day with " dyet " found; the total wages came to £6. 5s. 6d. and the cost of the " dyet " to £7. 12s. 2d. He had his trouble with the townspeople, who complained that he took too much toll. He answered, " I have provided at ech millne a sufficient Beame, and London weights wherby every man may weigh ther corne before it goes into the hopper and so also when it comes out that they may thereby the better know whether they be honestly delt with, or not ". He is described as a " contentious turbulent spirit ", but he had much to try him. In 1660 the restoration of the king threatened Hartley with the loss of his lease long before he had had time to reap the benefit of the money he had spent. By that time there was only one of the original feoffees surviving, Sir Cecil Trafford. Since the feoffees of 1647 had not been approved by him, they had no legal standing, and so the lease of the mills they had granted to Hartley was worthless. A letter of December 1st, 1660, from a friend in London explains the position.

" These for John Hartley, Esq., at Strangeways."

" Yesternight we waited upon Mr. Broome who was made a sergeant the last tearme; this inclosed will inform you with his opinion which indeed seemes little to favour your affaires." This is Sergeant Broome's opinion. " The estate in law doth

*The cloth was stretched and kept taut by being attached to the tenterhooks which were fixed to the tenter bars or frames. That is to be " on tenterhooks ".

remain in the surviving Trustee, and those put in by the vote of parliament with whom Mr. Hartley made the contract neither have or had any estate at all, and therefore Mr. Hartley's lease is utterly void, and no rent can be recovered of him. But the surviving feofee or such other as he shall make may recover the estate from Mr. Hartley in strictness of law and I doubt Mr. Hartley will have no releife in equity because his lease is void and no conformation can make it good, and if he should apply himself to the king to gett a reference to some p'sons of quality to compose the difference yet would not that bind except the surviving trustee would consent and therefore as Mr. Hartley rests I conceive he hath noe remedy in any ordinary court of Law or Equity but is to resort to the Parliament and how farre they will take it into consideration is doubtfull."

The next move was to petition the king to compel Trafford to enfeoff the feoffees appointed since 1647 and so legalise their position. The order was obtained from Whitehall but Trafford refused to obey it. He was summoned before the "Councill Board", but another letter from London warned Hartley that there was little hope of success. "I shall be verry reddy to give all the assistance thatt I canne macke at Corte and elsewheare. But in the meane time before Sir Cisell comes up to London if you can compose itt I think it would dowe well; for he refusing his Majesty letter, and now the Lords of the Councell order and thatt he will come and appeare before them and if he stand uppon the stricknes of Lawe I know nott how it may prove."

The rest of the story is told in a series of letters to Hartley from John Birch, who was staying at Clare House in London. The first of them was written on the same day as the one above, and gives the same warning. "It's to be feared that hee, Sir Cecill Trafford, will appeale to the Common Lawe as the standing judge of all controversies which the councell will scarce deny him. The issue I must needs say appeares doubtfulle to me and the rather because I heare there are counter workings but its best to resolve all into God's pleasure to whom only events belong. I have received six pieces (of gold) more from your brother which I intend to present the Secretary. I believe never the lesse that he will refuse them."

Four days later Birch, busy in employing counsel and preparing Hartley's case to put before the council, writes again. " Mr. Whittaker also the public notary told me that it would be very convenient to have either the statutes of the school here or a Coppie well attested, and that Coppies thereof be given to everyone of the Councell. The truth is without the statutes nothing can be done." A day or two later, January 29th, he writes more urgently, " I pray you make all haste to send the statutes. Send word alsoe whether Sir Cecill Trafford bee a convicted papist or not ; what reasons you can learne that hee alledgeth why he disobeyeth the order that so wee may before the councell be the better prepared to answer them ; what his carriage hath been since the receipt of the order ; whether he hath spoken any daring words such as I heare he hath, viz. that he careth neither for the king nor Cesar himselfe knowing what his right is ; that he is resolved to spend £1,000 before he will be burked in his business ; and send word also if you can wherein the Gentlemen nominated by his Majestie have manifested their loyalty to his Majestie lest he should object anything of that nature against them."

Then there is a gap of three weeks, at the end of which, on February 23rd, Birch describes the issue. " These for my much hon'd ffriend John Hartley Esq. att Strangeways, neare Manchester. Sir, The diligence required in your business by reason of the great vigilancy of our adversaries hath hitherto prevented my writing to you. At our first appearance before ye Councell the Chancellor being possessed with prejudice against us did so storme that Sir Edmond Nicholas tho' before resolved to speake on our behalfe was smit dumb, since when hee hath done nothing for us for feare of displeasing ye Chancellor." The Council referred the dispute to the two Lord Chief Justices. Lord Clare, in whose house Birch was staying, saw that he had a fair hearing before them. " When I came from Councell I told my Lord of Clare how the Chancellor had raged against us and would neither let us speake for ourselves nor have the benefit of Councell as was granted to our adversaries, yea when many of ye Lords of the Councell cryed out shame of it. Whereupon my Lord said, but you shall have Councel and justice too and thereupon sent to the too Lord Chief Justices or rather demanding that wee might

be heard with our councell before them which was granted." The result was a compromise, but one which favoured Trafford. Of the eleven feoffees which he was to nominate, six were to be of his choosing and five from among the other party. This was perhaps satisfactory for the school; for instance John Wickens the High Master was confirmed in his post, as a sound schoolmaster, although his predecessor Brideoak was now a feoffee. But it was fatal to Hartley's interests. John Birch hoped to overset the decision when the matter came before the council again for confirmation. He wrote, "ye report being made by ye Justices wee appeared before the Councel yesterday and tho' we had retained double Councel yet both failed. Ye one slipt away privatly, ye other was silent and never opened his mouth. I feare both were dealt with by Sir Cecill underhand."

The new feoffees deprived Hartley of the mills and granted a lease to the lord of the manor, Sir Nicholas Mosley. He, and his successor Sir Oswald Mosley, made a very good thing out of them. They were said to have got them at a very low rent, and the profits were certainly rising with the rapidly increasing population of Manchester. To meet the greater demand Mosley converted the fulling mill into a corn mill and erected a horse-driven mill in Hanging Ditch. But in 1716 he failed to get the lease renewed. He had been paying £250 a year, and he may have been outbid by the "sixteen principal gentlemen or traders of Manchester" who held the lease from 1716 to 1726. Their lease is missing, but in 1726 two professional men, a lawyer called Yates and a surgeon called Dawson, acquired the lease for £400 a year. They held it until 1756, but they had cause to regret their venture. Dawson, the more active partner, was reputed to be a violent disgruntled man, like Hartley in the seventeenth century; but it is more than likely that circumstances made him so. He was unpopular from the first. It is possible that the sixteen principal traders who had held the lease before him had lost it by what they felt were underhand methods, for one of the feoffees wrote a few years later that "several years ago a group of Manchester men offered the same or better rent than Dawson", and went on to suggest that he should be turned out and their offer, which still held good, taken. John Byrom's diary for December 17th, 1728, refers to them.

"At the Bull's Head with . . . upon a dispute about the mills I told him

Here's Bone and Skin
Two millers thin
Would starve the town, or near it ;
But be it known
To Skin and Bone
That flesh and blood can't bear it.

which made them all laugh much, and put an end to the controversy." Bone refers to Dawson, who was a surgeon; and skin to Yates who was a lawyer dealing in parchment. The origin of the dispute may have been the attempt of the new tenants to regain the monopoly of oat grinding. It had been neglected by Mosley, possibly because oats were not much used in the seventeenth century ; and also because kilns were needed for drying the grain, and it was not worth the trouble. But, with the increase of population and the growing shortage of bread grain in Lancashire, oats were more and more used in the form of oatcakes and porridge. But, failing to regain the monopoly for oats, Dawson refused to grind them at all, and concentrated on wheat and malt.

Malt grinding was very profitable. Manchester had many inns, and malt was easy to grind. But for that reason it was difficult to prevent evasion of the monopoly. A horse mill, or even a hand mill, could crush the malt as well as the wider stones of the school mills. Each year action was taken against illicit malt grinding, rising to a climax in 1732, when proceedings were taken against Sir Oswald Mosley for his horse-driven malt mill in Hanging Ditch. He could afford to fight ; the decree of the court to prevent his grinding was not gained until 1736, and he could not be induced to pay over the costs and damages until 1739. The feoffees were obliged to reduce the rent by £100 a year to Dawson, to lower the salary of the High Master, and to shut the school. When it was reopened it was difficult to induce the pupils to return for they had gone to other schools. From that time onwards a larger surplus was always kept in hand to meet legal costs.

The feoffees hesitated to renew Dawson's lease in 1736; they considered employing a steward to manage the mills on their behalf. They had been involved constantly in legal actions, and yet by farming the mills denied the school the chance of rising profits during the ten-year lease. If they were to have the trouble they might as well have the profits. For a few years they would renew only for a year at a time, hoping for a more "suitable tenant". Finally they renewed for another ten years, but reserved the right to cancel the lease at three months' notice. The reason for this prolonged hesitation is clear from what followed. The monopoly on which the school's income depended was in danger. Dawson, unpopular and unaccommodating, was damaging the school's interests; but no more suitable tenant could be found.

The struggle started in 1740 with the prosecution of Peter Royle, Baker and Flour Dealer, for withdrawing his grist from the school mills. The business of "Flour Dealer" was the real threat to the monopoly, for the monopoly of grinding wheat belonged to an economic organisation which was passing. The school mills had, till the eighteenth century, ground the grain which the housewife bought direct from the farmer in the market. Now a middleman was appearing who was performing this service; that is, he was buying the grain, grinding it, and selling either flour or bread to the housewife. Moreover the flour dealer was grinding his grain more than once, so that he had for sale very fine white flour, good for pastry, and a coarser flour fit for the servants' hall. Finally he was meeting the increased demand for grain in the overpopulated area of Manchester by importing from the south, by sea to Liverpool. To the flour dealer the school mills were a hindrance in several ways; they still made it possible for people to buy their own grain and get it ground; to end that would be to strengthen *his* monopoly in buying grain and selling flour. The corn which was being imported came at the dealer's risk, yet it must be ground at the school mills, which not only profited but would not, or could not, grind fine flour. One complaint against Dawson was that, when a flour dealer asked that his grain should be ground on the (French) blue stone and not on the (Derbyshire) grey, Dawson said he would "grind as he pleased". In short the flour dealer

wanted to control the whole process from farmer to housewife, and to escape the risk of prosecution for infringing the monopoly of the school mills. By 1750 they had established themselves in their own mills round about Manchester and were prepared to challenge the monopoly. The most considerable firm, that of George Bramall and Thomas Hatfield, were tenants of the Travis mills, barely a quarter of a mile about the Town's mill which belonged to the school. They were importers of corn, millers, bakers and flour merchants. Their carriers touted for custom, first after night-fall, and then openly by day in the streets of Manchester. In fact Bramall courted the legal action which was taken in 1754, for he had the support of other dealers, and even of two of the feoffees of the school, the Lords Strange and Warrington. Lord Strange was the owner of the Travis Mills, and Lord Warrington owned other mills in the district. There was never any doubt in the minds of the feoffees and their legal advisers as to what they were up against. Here is their version of it, written at the end of the struggle. "About eight years ago, some of the bread bakers in Manchester commencing flour Merchants, and having got mills of their own upon the new Construction, which they call Manufacturing mills, began a new method of grinding their Bran several times over, and with that and other mixtures, increasing the Quantity of flour, so as to be able to sell it cheaper than it could be had from Grain ground in the Old Way, which induced many of the Inhabitants to buy their Flour ready ground, rather than in the grain; and others did so through Indolence, without inquiring where, or how it was ground."

It is necessary to stress this, for one of the arguments used by Bramall was that the school mills were not able to grind all the grain needed by a rapidly growing Manchester. In fact the mills were getting less and less custom from 1750 onwards, simply because the inhabitants of Manchester were buying flour instead of grain. So Kenyon, the school solicitor, wrote: "If it is said that though we lose the monopoly, yet we can compete for custom if we grind as well as they do, then they are strangers to this country. Of late a trade of selling flour and bread has prevailed here. Little wheat comes to market,

and what does is bought up by bakers. Hence the mills for a few years have had less brought to them and will have less still with the loss of custom ". So Dawson had to arrange a rush on the school mills to prove their inadequacy. For several days huge quantities of grain were sent to be ground. The mills worked night and day to deal with the rush, but it was weeks before the flour was taken away again.

The feoffees won their original action against Bramall in 1754. The law could not take into account anything but the legal rights of the school, as expressed in the 1525 deed, and Bramhall or his solicitor was obliged to challenge the legality of the monopoly itself. So the feoffees were bound to trace their claim from the the original charter of the lord of the manor to the burgesses of Manchester in 1301, to the foundation deed of 1525 which bequeathed it to the school, and thence to the various decrees of the Court of the Duchy of Lancaster which enforced it, down to the witness of living men. Old mill carriers, millers, and millwrights of sixty or seventy testified that, within their memory, the custom had been acknowledged by " all ancient creditable substantial housekeepers of Manchester ", and that those who broke the custom had always paid a fine. From the legal point of view it would have served Bramall well if he could have shown that even though the monopoly had once existed, yet it had been neglected and was therefore obsolete. One neat trick was the production of evidence that Dawson himself had used the Travis mill before he was tenant of the school mills. But Dawson found the old carrier of the Travis Mill, Allen Wrigley, who admitted that he had taken his grain there unbeknown to him. All the time the defendant was working in the dark for he did not seem to have had a copy of the 1525 deed. To the last the complaint was that " the original grant hath not yet been produced ; they said they intended to print their charter, but it is presumed that they have since been advised that the printing would make some discoveries that might impeach their assertions ". The school won its case and was awarded £1,500 damages and costs against Bramall in 1757. But that was not the end of it. Bramall's solicitor delayed judgment by summoning fresh witnesses, and then by issuing

a cross suit. The action rambled on, a mere pretence. Meanwhile a quite different attack on the monopoly came from another quarter, challenging not the legal right of the school in the courts, but the expediency of the monopoly in Parliament where such an issue could be entertained.

On November 11th, 1757 a town's meeting of Manchester citizens proposed that the wheat monopoly should be abolished and only the malt monopoly retained by the school mills. But the administration of the mills should be taken out of the hands of the feoffees and given to a public body of trustees, selected in alphabetical order from among the £30 householders of Manchester and serving for three years. The feoffees were to be paid a fixed rent and, if the profits of the mills failed to meet it, the deficit was to be met by a tax on house occupiers levied on the basis of the window tax. If, on the other hand, there were a surplus, it should go to the poor law fund. If the feoffees refused to grant this perpetual lease to the new trustees then a petition would be made to parliament for an Act which would enforce it. There was much to be said for this scheme. Its promoters disclaimed any connection with Bramall. No baker or corn dealer was to be eligible as one of the trustees. It expressed the irritation of the ordinary householder who wished to buy his flour ready ground, without being liable to prosecution which was described as " a sword hanging over our Heads by a single thread, and the Tenant, like one of the destinies with the fatal sheers, ready to drop it on us ".

As for the malt monopoly, the complaint was of constant dishonesty of the servants employed at the mills, against which there was no redress except by expensive legal action against feoffees who could go to law when it pleased them since the school funds bore the cost. Moreover it was said the mills were out of date and inefficient. So the new trustees proposed to rebuild them, and to prevent fraud by employing a steward to check the servants, weighing the malt before and after grinding, and charging a shilling a load instead of taking a proportion of the grain. Leave would be obtained to make it possible for complaints to go to a local J.P. instead of London. Finally the accounts would be audited at the yearly vestry meeting which was public.

One objection appeared in verse. John Byrom was now a feoffee, and his point of view had changed.

> " For the good of the Town, they would have us convey
> . . . the Mill, and the lands appertaining thereto.
> Now this at first sight, one cannot well do ;
> For in Persons maintaining a Charity Trust
> Such a sudden Compliance would hardly be just."

The feoffees had no power in law to do as the townspeople wished ; they were bound by the deed of 1525 which forbade the grant of a lease of longer than ten years. Nor was the monopoly, which was a form of property, theirs to give away. They had no more power than the trustees of Chetham's Hospital or the dean of the Collegiate church, to hand the school's property over to the administration of trustees selected, as the following verse says, in alphabetical order.

> " We Feoffees have the Trouble ; the School has the Gains.
> Of what use is reproach for our well meaning Pains ?
> Not withstanding Defects, let the Alphabet doubt
> Whether College, or Church, be entirely without.
> And propose it to *them*, that Rotation of letter
> May take their belongings and manage them better."

But even if the feoffees had been free to accept the terms offered, were they adequate ? The income guaranteed was to be based on the average of the previous twenty years. A change in the value of money might have halved its worth. The rent had increased from £130 a year in the seventeenth century to £460 in 1756. Why should any surplus go to the Poor Rate to benefit those who paid the rate rather than the school, who would spent it on exhibitions to send boys to the universities ? It was a grudging offer, which was to cost its promoters nothing. There was no suggestion of buying the monopoly and then abolishing it. It had considerable value in the eighteenth century. For instance, in 1771 the Right Honourable J. Smyth bought the manorial mills of Bradford, and although the custom had been neglected for years, he managed to enforce it after a seven-year lawsuit against the bakers and flour dealers, who protested that his mills could not grind the corn required by a

growing industrial town within the statutory twenty-four hours. In 1795 the townspeople tried to buy him out but could not raise the £12,500 he demanded. Leeds paid £13,000 out of the rates in 1838, and Wakefield paid £21,500 in 1859 for similar monopolies, both to private owners. The feoffees were justified in protesting that " Customs of this sort prevail in many parts of the kingdom and in some large and populous towns ". They might have pointed out that, if Hugh Oldham had not bought the monopoly, it would have passed along with all the other manorial rights to the Mosley family. Would there have been any question of Sir Oswald Mosley parting with them for nothing? In the middle of the nineteenth century Manchester paid his descendant £200,000 out of the rates for his market dues.

The school solicitor's opinion was that the proposal was " a private selfish job to appropriate the surplus of the profits of the mills ". The feoffees were convinced that the offer was no more than a renewed attempt of the flour dealers to destroy the monopoly. In Byrom's words,

> " One would not suppose that, to make a Bill pass,
> Any person conceal a snake in the Grass? ".

The " grass " was the assertion of the promoters of the scheme that the mills were incapable of grinding the grain needed by the growing population of Manchester. There were serious shortages of grain in the area during the eighteenth century. The population was growing too fast for local supplies to be sufficient, and the transport of grain from other areas was inadequate. Prices rose and riots were frequent. In 1756 £7,000 were raised by public subscription in Manchester to supply flour to the poor. There was a serious food riot in June, 1757, and another in November. Hence any slowing up of the supply of grain due to the necessity of having it ground at the school mills was a serious matter. But were they inadequate? Byrom wrote,

> " They object insufficiency to a poor Mill,
> That for *want* of its Grist is obliged to stand still ".

In other words, the inability of the mills to grind all the grain needed by Manchester could hardly be urged as a reason for depriving them of the monopoly, if the mills were only working

half time. They might be inadequate, but the scarcity of flour could not be attributed to their inadequacy so long as they were not fully employed. The feoffees declared that the shortage was due to the activities of the flour dealers, and that the monopoly alone stood between them and their complete control of the grain supply. The legal obligation of the school mills to grind all grain brought, secured customers "from the exactions of the flour dealers whose mills were not obliged to grind within a limited time or at a fixed price". When the monopoly went there would be no way of preventing engrossing. No private buyer could then buy grain, for no mill would grind it for him. The flour dealer would control the grain market, simply because he alone would have the mills to grind. He could thus force the farmer to take whatever price he chose to offer, and charge the public what price he liked for the flour.

This was widely believed in the eighteenth century. The following quotation from the Gentleman's Magazine of 1758 has the same theme. "Many of the millers are now metamorphosed into wholesale mealmen or flour merchants. Do these gentlemen condescend to take a poor man's grist? Do not the greater part grind wholly for themselves. Every flour merchant is now the ruler and the Lord within his district. The farmer looks upon this dealer as his oracle. Inquire how the markets go, and the answer frequently is, The miller gives so and so".

It was also believed among the working class of Manchester. In the riots of June, 1757, the mob broke Bramall's windows and ransacked his warehouse in Toad Lane; in the following November they plundered the Travis Mill and broke the stones and tackle there. Bramall went in fear of his life. After each riot he wrote to Whitworth's Manchester Advertiser to deny the stories that the mob had found "great Quantities of Acorns, Bones, Whiting, Chopt Straw and even Horse Dung" in the hopper of the mill, which was about "to be ground down with Corn and made into flour for sale".

A pamphlet by Tim Bobbin, called "Truth in a Mask, or the Shude Hill Fight", published at the time, attributed the scarcity to a conspiracy of certain "Sons of Belial" to buy all the corn in the land of Chester, so that when "the people faint

for lack of Bread, we will sell unto the People Bread for their money at our own Price". George Bramall is referred to as "Bramaliel, one of the chiefest sons of Belial".

The feoffees missed no opportunity. Among the school papers is a rough draft of a proposed bill to make illegal the owning of mills by bakers and flour dealers. "Whereas many notorious and great tumults and Riots have of late happened in many parts of this realm, occasioned by Swalers and Badgers and other evil minded persons engrossing great quantities of Corn and Grain and afterwards grinding the same into meal or flower at their own milns and often adulterating such meal, by which evil practices the price of corn and grain has been greatly enhanced, and thereby an Artificial Dearth of corn has been artfully contrived, not withstanding almighty providence of his great mercy has been pleased to afford a plentiful crop of all sorts of corn and grain", and so on.

At the same time every effort was made to rebut the charge that the school mills were incapable of grinding the grain sent to them as well as the flour dealers mills. £100 was spent in building a warehouse, two stories high, and a dressing mill "for the conveniency of the bread bakers and dealers who wanted to dress their wheat after it was ground".

In May, 1758, Thomas Hudson, the school's lawyer in London, wrote, "You may soon expect that corn will be sent in and experiments made of the Power of the mill; we beg that all the mills may be put into as good order as possible, to be ready to grind as much as shall be necessarily sent in for the consumption of the town". A letter in reply describes how the opposition's lawyer had "sent a man down from London to pick up what he can in support of the Allegations; who, whether a knight of the Post, or otherwise, is not certain; but he behaved so badly here, that he was taken up by the officers of the Town and committed a prisoner to the Bang Beggar's House and afterwards taken before a J.P. till the petitioner's solicitor was sent for to release him".

The final stage of the dispute took place in London in the autumn of 1758. Two of the feoffees went there with full authority to make the best bargain they could. It was clear

that nothing could save the wheat monopoly, not because the arguments given above were very convincing, but because it would have been intolerable to have maintained the monopoly once agitation had been raised against it over a period of years. A school was more sensitive to public opinion than an individual, and private property was more respected than trust property in the eighteenth century.

The monopoly of grinding malt was retained, though with some modifications; the wheat monopoly was lost and some sort of compensation was given. At first the feoffees were offered a sum of money sufficient to produce an income of £100 a year, but when it was found impossible to raise the money they were obliged to accept freedom of the school estates from the payment of parochial taxes instead. It is not possible to estimate the worth of this for there are no accounts before 1772. The feoffees were reluctant for they feared that the exemption might prove a further cause of friction with the townspeople. This settlement was embodied in the act of 1758, described in its preamble as "An Act for discharging the Inhabitants of Manchester from the custom of grinding their corn and grain at the School Mill, and for making a proper recompence to the Feoffees". Only an Act of Parliament could have modified the terms of the deed of 1525. Even so the modifications were cautious. For instance the two mills which had been used for corn grinding, the Town's Mill and the School's Mills, were now let to separate tenants who were bound to maintain stones for grinding any grain brought to them. The tenant of the lower mill was Peter Walker, a wire worker and pin maker; and for some years the tenant of the upper mill was William Edge, a chapman, who used it as a cotton mill. But, from his bankruptcy in 1789, it reverted to corn milling till its decay in the second half of the nineteenth century.

The malt mill was the old Walke mill on the other bank. That was not let, but was put in charge of the school receiver. By the 1758 act the old custom of taking a proportion of the grain which had led to so much abuse and complaint was abolished and a fixed charge of a shilling a load allowed for grinding. The task now was to make up for the loss of the wheat monopoly

by increasing the profits of malt grinding. The growing wealth of Manchester should have made this possible. It was a town of innumerable inns brewing their own beer, to which weavers resorted when they came in to the warehouses with their finished cloth. It was their habit to make a day of it before returning to another week of work. Their relaxation was to the ultimate benefit of the malt mill. But the rapid change in the value of money made the fixed charge of a shilling a load for grinding, hardly profitable. For twenty years after 1772, for which we have the accounts, the receipts of the malt mill total between five and six hundred pounds a year ; then they rise to a level of nine hundred a year with the exception of two slumps of 1794–95 and 1800–01, which reflect years of economic crisis. But the increase in receipts, coincident with the war with France, is wholly absorbed by increased costs of running the mill, so that in 1808 the feoffees sought counsel's advice on what they should do. The profits of the malt mill, the school solicitor wrote, were actually declining, because the " value of money had materially altered since 1756 ". They could get as big an income by letting the mill at a yearly rent, for the demand for water power was very great. But to do that they must be freed from the obligation of grinding malt, and would wish to get some recompense from the innkeepers of Manchester. But counsel replied that there was no hope of recompense for giving up the monopoly and very little hope of freeing the school from the obligation of providing a mill to grind malt. That was bad news for, from 1808 to 1813, the receipts dropped back to the pre-war level, although the expense of running the mill remained high. It was a prolonged period of great distress for the Lancashire weavers. The most convincing proof of the genuineness of the feoffees' complaint is their failure to find a tenant for the malt mill who would work within the terms of the monopoly. In 1810 they offered a twenty-one years' lease but no one would give a reasonable rent.

Yet the income of the school had now reached £2,000 a year, and there were several thousands invested in the 3 per cent. war loan. That astonishing increase was due to the power given to the feoffees by the 1758 act, to sell any of the school property other than the mills, to which the obligation to grind was

attached. Between 1787 and 1800 the field at Ancoats, on which the mill horses had been pastured, were sold on chief rent, part to private buyers and part to the Ashton Canal Company. The chief rents amounted to over £1,000 a year.

This account of the administration of the school endowments from 1515 to 1832 ends with achievements of Josiah Twyford, who was appointed receiver in 1809. Since the feoffees had taken over direct control of the malt mill in 1758 the office of receiver had become much more important. The 1515 deed insists on surety being demanded for the man appointed as receiver, but there are several references in the seventeenth and eighteenth centuries to receivers whose accounts were unsatisfactory. In 1777 Christopher Moorhouse was asked to produce his accounts for the past seven years, and then dismissed. In 1807 John Grime suffered a "sudden derangement" and his sureties had to pay £100 towards a deficit of £158 in his accounts. Josiah Twyford, who was then appointed, had been a watchmaker and silversmith until the loss of an arm made that trade impossible.

Twyford's first act was to sack the mill hands for pilfering, as a preliminary to tightening up the monopoly. By 1815 the receipts had risen to £1,300. Then, in 1819, he produced a plan to build a new malt mill at a cost of £3,000 out of the surplus created by the chief rents of the Ancoats land. The new mill was to be put up on the site of the lower mill. The fall of water at the centre mill was to be added to that of the lower mill, so making possible the use of a larger and more powerful water wheel. Access to the new mill would be by Long Mill Gate instead of the badly paved lane from Hunt's Bank along the other side of the Irk.

The mill took more than a year to build. The most important part of the reconstruction was the alteration of the weirs, and that had unforeseen results. When the weir to the centre mill was removed it caused a fall in the level of the stream, and temporarily left a few feet of sloping bank clear of water. James Howarth, one of the occupiers of the river-side houses, promptly built a wall along the foot of his garden at the edge of the water. This might have had the effect of forcing the stream away from

the mill wheel. The school claimed that the 1525 deed gave it the bed of the Irk along with the fishing rights, and that tanners who dried their skins on the banks had always acknowledged the school's claim. But the hindrance was not removed until Howarth died in 1828, and the school could buy his property and remove the wall. Another anxiety arose when the lower weir was raised in height, for that brought the level of the water up again to four feet higher than it had been before. For a time it was feared that the water might undermine the walls alongside the river, which had previously been clear of water.

The mill was finished in 1821 ; in the first year of its working, the receipts were £1,000 higher than in 1819. For the next fifteen years they averaged £3,000 a year. In addition, a set of stones for grinding oats and beans for farmers produced £500 a year.

Twyford completed his work in 1823 by utilising the strip of land on which the centre mill had stood. The croft behind it had been sold in 1813 to the church for a cemetery. Twyford made a bargain with the firm of Moss Gardner to build a woollen mill for them between the cemetery and the river. The firm was to provide the machinery and the steam engine to drive it, for the water power had gone. The rent was 7½ per cent. of the cost, which was £1,500.

The feoffees' minutes for October 13th, 1830, include this resolution. " It appearing from the accounts that there is now a large surplus in favour of the school and that the flourishing state of the mills is mainly attributable to the exertions and good management of the Steward—Ordered as an inducement to further exertions his salary be increased £100 per annum ". The compliment looks impressive in the minute book which rarely records more than routine business, but the increase of salary was a mockery in contrast to the extraordinary success of Twyford's venture. For fifteen years he produced a surplus of over £1,000 a year. Undoubtedly he stole a march on malt grinders in the vicinity, who were outside the monopoly area. The increase of custom cannot have been due, in those grim years, to a great increase in the consumption of beer. And, although he was careful to check evasions, it is very unlikely

that evasion accounts for the difference in receipts between 1809 and 1821. The efficiency of the new mill with its greater water power had given it an overwhelming advantage over the malt mills round Manchester, so that it must have secured the custom of many who were not obliged to grind there. Twyford's constant watchfulness secured honest dealing and quick delivery, so that the utmost advantage was derived from the capacity of the mill to grind the greatly increased amounts of malt brought to it.

Twyford died in 1832. For five years the mills continued to flourish. But between 1837 and 1839 the receipts of the malt mill dropped from £3,500 to £1,500 a year. Then followed a steady decline; the receipts were little more than £1,000 in 1849, half that in 1870, and negligible in 1880.

The trouble had started early in 1834 when an emergency meeting of the feoffees was summoned to consider the report of a meeting of publicans which had appointed a committee to see the member for Manchester, as a preliminary to an Act of Parliament which should abolish the malt monopoly. The publicans produced a long list of complaints of mismanagement. The feoffees did all they could to meet them. Neglect and insolence on the part of the mill servants were checked. Young Twyford, who had succeeded his father as receiver, was warned that he must not deal in malt on his own account, lest he should be suspected of pilfering. A year or two later he was dismissed for negligence. Next a ten horse-power steam engine was installed to increase the water power of the mill, and arrangements were made with Caistor, the tenant of the Upper or Town's mill to help with the malt grinding whenever the school mill could not grind promptly. Caistor was prepared to grind malt for sixpence a load. This was half the price which the school mill was allowed to charge by the 1758 act. In the late eighteenth century a change in the value of money had made a shilling too little; another change had made it too much. The feoffees, therefore, lowered the charge to ninepence a load. But their efforts seemed wasted. The school solicitor saw Mr. Law, the most active and influential of the publicans. Law dismissed the complaints against the working of the school mill as "magnified

and not worth serious attention ". " The parties " he added, " interesting themselves against the monopoly did so on the broad basis that it was an unjust and unequal tax on the public to which they ought not to remain subject ". He offered " a moderate assessment on public house property " which would bring in £800 a year for the support of the school. But that would only continue for a limited number of years.

In the end no bill was brought before Parliament, for it was found easier to evade the monopoly, not by sending malt to be ground at the Salford mills, but by moving the breweries outside the boundaries of Manchester. That was the explanation given for the sudden drop in receipts from the malt mill from £3,723 in 1836, to £1,739 in 1839. There is a similarity between the failure of the malt monopoly in the nineteenth century and the loss of the wheat monopoly at the hands of the bakers in the eighteenth century. So long as beer was brewed by the publican the malt monopoly was safe because the publican could not move his inn ; but when brewers began, more and more, to provide the beer used at the inns, it was only a matter of time before it became worth the brewer's while to move out of the monopoly area, for he could serve the publicans as well from Salford as from Manchester. The sudden drop of receipts of malt grinding between 1836 and 1839 was due to the decision of the larger brewers to move out of Manchester ; the gradual decline of receipts, which continued throughout the century, was due mainly to the disappearance of the publican who brewed his own beer. In 1839 such publicans had to make their peace with the school, for the proposal to abolish the monopoly by Act of Parliament had been abandoned. The new receiver, Meller, was very ready to lower the charge for grinding to sixpence a load, which was no more than what other mills charged. There was then no temptation to evade the monopoly by sending the malt secretly to Salford mills.

Meller made a gallant effort to offset the decline in the malt takings, by developing the business of the " wheat section " of the malt mill, in competition with other mills in the town. Despite its name it did not grind wheat, but " farmer's grain ", beans, peas, barley and oats. By 1849 Meller had increased the

income from this business from less than £700 to £1,400 a year. His success involved him in a little price-cutting campaign. In 1852 receipts were down to £700 as a result of other mills cutting their charges. Meller cut his, until at the end of two years they agreed to a mutual increase again. But the running expenses were heavy. From the start Meller pressed for the installation of a larger steam engine, to supersede water power. In 1839 he reported that the mill would "never yield profit from this uncertain stream, the Irk". During the previous six months, the mill had been idle a third of the time from flood or drought, so that customers could never depend on having their orders done to time. To prevent them taking their grain elsewhere he had paid other mills to grind it. Year after year he persisted. In 1844 he said he could treble the business done if he had adequate steam power, whereas he had lost £400 that year since the mill was "one day in flood, and the very next short of water". He got his steam engine in 1846, a high pressure twenty-five horse-power engine. Gradually the receipts increased, until in 1855, when he retired, they were back to the £1,400 level for the wheat section of the mill.

The feoffees went to great trouble to get a good man in Meller's place. One of them went down to Nuneaton to induce William Hodson to take the job at an increased salary and the promise of yet more if he could gain a permanent increase in the prosperity of the mill. He only stayed a year; his brother S. H. Hodson took his place. The feoffees recorded that William Hodson's resignation was "a serious loss to the charity". In his short stay he reviewed the prospects of the mill. He showed that the wheat section had, for the last ten years, been running at a loss of £60 a year; the so-called profit of £700 to £1,400 was only arrived at by crediting a far too great proportion of the overhead charges to the malt mill account which, therefore, showed less profit than it should have done. Moreover much of the apparent custom of the wheat mill was not real; one of the best customers was the City Omnibus Company, which paid five shillings a load for splitting ten loads of Indian corn. The five shillings included carriage of the corn from their warehouse in Salford and delivery to their Longsight stables. Their yearly account of £105 represented a loss.

Hodson was less happy in his other judgment. He could find no serious evasion of the malt monopoly, simply because, at sixpence a load, it was not worth the risk. But he also saw that the mill's custom was with publicans brewing their own beer, who could not remove from the area, and a few small breweries who found the cost of removal not worth while. He argued that, as the school had a monopoly of malt grinding, it might as well charge the shilling allowed by the 1758 Act of Parliament, since it had nothing to fear from competitive charges of other mills. The increase would bring in another £400 a year. A bold measure ; in the year after he left the receipts rose by £300, but in the next year most of that had been lost by the removal of two of the malt mills' largest customers, brewers who had not thought it worth while to shift before. The publicans who could not move tended to give up home brewing, so that in the next twenty years the receipts from the malt mill dropped to nothing.

That was the end of Hugh Oldham's endowment. The School, or Lower mill, which had been used to grind malt, was let in 1857 to a tenant who first provided the power necessary to run the malt rollers which were moved into the warehouse next door, and later ground the malt himself and paid the school part of the proceeds. The Town's, or Higher, mill, let since the eighteenth century to a corn miller, fell vacant in 1858. Since it had only water power, no tenant could be found for it, so it ended its days as a warehouse of a cotton waste merchant. These two mills, and the site of the third mill taken down in 1819 in Walker's Croft, ultimately appear in the receiver's yearly account in the form of chief rents from railway companies. The line to Victoria Station dates from the early 'forties ; its widening absorbed the Upper mill in 1875, and the Lower mill and Walker's Croft in 1883. For this the Lancashire and Yorkshire Railway Company paid a total of £1,600 a year in chief rents.

Some Account of a Research Adventure within the Industrial Pattern

By Cecil J. T. Cronshaw

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Honoured as I feel by this invitation from your Society and seeking to pay my own due compliment to the Society for the personal opportunity this afforded, it seemed that I could best serve this end by an endeavour to give you some account of the rise and development of a research organisation within one industry. True it is that I shall not give you what Sir Arthur Quiller Couch once referred to as "an indecent exposure of one's personality", since such likelihood is not even at risk because the adventure I have to recount is far removed from any mere personal exploit and is indeed a many-sided story, with a multiplicity of principal characters.

Many names of persons, therefore, will you hear, and for this in a tale of adventure no word of apology is needed. There can be no deeds without persons; no discoveries without discoverers; no inventions without inventors. Perhaps even a note of realism might be added to present day affairs if we could think of organisations as a collection of persons rather than an arrangement of positions.

I confess freely at the outset that though early settled upon the subject matter of this lecture, the problem of an appropriate title nevertheless gave me some concern and its ultimate issue until a fortnight ago, as your Secretary well knows, and your printed Calendar betrays, eluded a satisfying answer. For the delay and seeming frustration to Mr. Clayton I tender an apology, reserving in my defence the plea of what Lord Moulton once termed the "delay of deliberation". Even now I have a feeling that the title I have chosen calls for some annotation. But the word "adventure" I believe is appropriate since I am willing to accept any or all the meanings offered to the enquirer by the Shorter Oxford English Dictionary. Let me quote them to you. That which happens without design; a chance occurrence; a venture or experiment; a hazardous enterprise or performance; a pecuniary venture; a speculation; adventurous activity; enterprise; risk; jeopardy. Just as the range of meanings in our language have thus varied since the days of Middle English

to the present time, so I guess that over the fifty or so years of which I shall speak there have been periods when some of the meanings I have read out to you were the aptest description of what was actually taking place. Some of you may require a word of explanation of "pattern" in the sense of "industrial pattern", but that I hope to clarify as I proceed, if I may thus solicit your patience for a short while.

This account relates to the research organisation of Imperial Chemical Industries, Dyestuffs Division, but the present entity reaches back into time and so for a proper understanding we should begin at the beginning. There were Read Holliday & Co. in Huddersfield; Levinstein Limited, Blackley, Manchester; Claus & Rée, in Clayton, Manchester; British Dyes Limited, Huddersfield, and British Dyestuffs Corporation in Manchester; Scottish Dyes in Carlisle and Grangemouth, near Edinburgh; The British Alizarine Company, at Silvertown, near London, and latterly in Trafford Park, Manchester; Oliver Wilkins & Co. in Derby; Emco Dyestuffs in Hull; Leech Neale & Co. at Spondon; and Alliance Chemical Company in Broadheath, near Altrincham. This list of the companies which have become merged into the present undertaking is roughly in chronological order, but the intervals of time between the different events vary greatly, and for the purpose we have in view this evening there is no need to trouble you with a series of dates. But I ought to say that the two companies of Claus & Rée and The British Alizarine Company endow the present organisation with a direct lineage from the genesis of coal tar dyes manufacture in this country; indeed, with the first manufacture anywhere in the world, viz., W. H. Perkin's pioneer attempt in 1857.

One admits freely that the research adventure differed in intensity within these different firms and also varied at different periods, but it is important to realise that in each and everyone of them it always existed—radiant, lambent, decadent if you like at times and in turn, but never absent.

I can speak from personal knowledge only since the beginning of 1915, but in the early history of these concerns were names that should not escape the record. With Read Holliday worked Mansfield, who had the privilege of working with Faraday and

to whom we owe the separation of benzene as a substance from coal tar. This same firm made a discovery (Vacanceine Red) which heralded the "para-red" process, which as we know now was an original step to the discoveries of the so-called naphthol colours discovered and developed years later in Germany by the Griesham Electron Company, and now the basis of those diverse processes which constitute a substantial part of the present technology of dyeing and particularly calico printing. A good example if you like of the deferred penalty involved by the failure to pursue and exploit an original successful idea. But there are many examples in this Industry, and may be in others, of how fatally easy it is in the early days of an initial success to mistake a whole continent of endeavour for a local enterprise. G. T. Morgan (afterwards Sir Gilbert and sometime Professor of Chemistry at Birmingham, later Director of the Chemical Research Laboratories at Teddington), first worked with Read Holliday on dioxy naphthalenes. Dr. Alfred Rée, originally an active partner in Claus and Rée, and afterwards a President of the Chamber of Commerce in this city. Dr. Rée had the unusual experience of both poetic justice and the turn of the wheel full circle in that having retired from the Industry he was subsequently enabled to play a part in the Renaissance of the Industry. With Levinstein Limited there was, as you know, Ivan Levinstein, a many-sided character, the founder of the Company, a friend and helper of Rubenstein, the pianist; a President of the Manchester Chamber of Commerce; and a figure in the chemical industry, an expert in patent law, and an advocate of many reforms in that department of law which were adopted in due course. Dr. J. C. Cain was at Blackley for some years before he became Editor of the Journal of the Chemical Society, a post he occupied until he died in 1921. There were also many continental chemists in the industry. Montvillier, Elkhell, Belart, Petrozech, Thevanaz, and Badier with Read Holliday. Hirsberger and Hertz and others were with Levinstein Ltd. It is interesting to note that whilst there is no record of any special achievement to the account of Hertz whilst working at Blackley he later went on to the firm of Cassella in Frankfurt and discovered not only many novel so-called sulphur dyes but the famous Hydron Blue.

This dyestuff has a special significance in that to an extent it contained for the first time the character of two great classes of dyestuffs, viz., the Sulphur class and the Vat dye class. In the realm of dyeing technology there was an extended battle between the deeply entrenched synthetic indigo and the newly arrived Hydron Blue.

Within my own recollection are names such as Sir Robert Robinson, President of the Royal Society and Waynflete Professor of Organic Chemistry in Oxford, who was Director of Research to British Dyestuffs Corporation in 1920; Sir Ian Heilbron, Professor of Organic Chemistry at Imperial College, worked for a time in the laboratories at Blackley, as did Professor Clemo, now at the University of Durham; Professor W. H. Perkin, son of the discoverer of mauve and also in his time Professor of Organic Chemistry at Manchester and then Oxford, was an active Director of British Dyestuffs Corporation; Sir Martin Forster, before he went to the Salters' Institute and thence to the Tata Institute at Bangalore, was a Director of British Dyes Ltd. Professor Green, who during the greater part of his life served in the dyestuffs industry in this country, shared in its vicissitudes and tribulations and finally forsook academic life in order to direct the work of a research laboratory in Blackley; Dr. Herbert Levinstein, a former President of your Society, who had a great part in the early renaissance of the industry and at all times a zealous advocate of the inevitable part in the pattern that research must have.

My company, Imperial Chemical Industries Limited, as a solution to its own problem of organisation has chosen (and in the course of time refined) a system of arranging its manufacturing activities into groups of related or near-related products. Such groups are termed Divisions. Thus we have the Plastics Division; the Paints Division; the Alkali Division, the General Chemicals Division, and so forth. The Dyestuffs Division is one of this number.

To each of these Divisions, the company donates a complete industrial pattern, thus these units of productive activity become translated into units of industrial enterprise within the company,

and are responsible within their determined ambit of responsibility for production, for selling, for research, and for development. Wherever appropriate the pattern is further extended since the fundamental conception is that each so-called Division shall have at its disposal all the tools, so to speak, for the job.

I promised at the beginning some further comment on this idea of pattern in the sense of industrial pattern. I have, I think, just given you an example of its meaning. Some three years ago, I tried to develop this notion of pattern within industry before the Textile Institute. Perhaps I may be allowed to repeat something I said then, " Research and production within industry are patterned together in an abiding relationship. Research has been defined as the research for the repeatable experiment and so one could define production as the regularly repeated experiment, but it cannot expect to continue if it be merely repeated without improvement year in and year out. The ability of industry to continue manufacturing is in the long run also its ability to continue selling. And so selling is part of the pattern. We sometimes forget that production and selling are merely different names for the same objective. They must over a period coincide or grave penalties will be incurred ".

The products within the sphere of the Division to which my address tonight mainly refers, viz., the Dyestuffs Division comprises the following wide range of products—all synthetic organic chemical products :

SYNTHETIC DYESTUFFS of all kinds and classes ;

PIGMENTS, excluding natural pigments ;

Those organic chemical products which have the property of aiding and controlling the vulcanisation process of natural rubber, the so-called " RUBBER ACCELERATORS " ;

Synthetic substances of an organic chemical nature used in admixture with natural rubber in its fabricated forms which help to delay and resist its liability to perish. The so-called " RUBBER ANTI-OXIDANTS " ;

Those synthetic substances which, not being soaps have special deterging properties. The so-called " SYNTHETIC DETERGENTS " ;

Synthetic INTERMEDIATE products mainly for the manufacture of dyestuffs ;

PHARMACEUTICALS.

The product built up from " coal, air, and water " by means of the synthetic process of organic chemistry (" NYLON POLYMER ") prior to being melted and extruded through fine orifices into a fine filament yarn (NYLON) for use in the hosiery and textile trade.

As we observed earlier on, all the units which in the process of time became part of the present Dyestuffs Division of I.C.I., had invariably a spirit of research within their pattern and this important and, as I believe, crucial tradition of the dyestuffs industry should be steadily maintained and nurtured. It was in fact a characteristic throughout the development of the Dyestuffs Industry in Germany ; it was a characteristic of both Levinstein Limited and Read Holliday & Company. This spirit of research dwelt within the production departments and there was no exclusive separation of this function into a formal research department.

In the early days of the renaissance of the industry this characteristic wedded state of production and research tended to become obscured by the creation of a formal Research Department. Research is in truth an attitude of mind and is the exclusive mental possession of no single department. Indeed, all our works have what are termed Experimental Departments at their service which are within their own direct control. It is thus that we endeavour to link the process of manufacture with a capacity to improve and refine. Even over the years we have not in our view accomplished the intensity in this joint endeavour which we feel is to be desired or it is possible to attain.

Having explained that the desire and the capacity to research are widespread over the full pattern (and we shall see later an example of such a spread) I may go on to speak of what is called The Research Department, wherein research is in its so-to-say state of " single blessedness " in that it is the whole duty of the department.

The department is organised under a Research Director, who has a place on the Board of the Division which is the stage at which the full pattern of the Division is assembled and is for most practical purposes the effective direction. It is not our practice to seek to distinguish between the various categories of research which the public have been taught by some over-tidy and classifying minds, to divide research work. Consequently we rarely use such unfortunately common terms like "pure and applied research", "fundamental research", "long distance research". Many problems before their solution pass through phases that could be described in these terms, and the work of any research organisation should as the price of its abiding value be a various mixture of all types of research effort. Indeed, we agree entirely with Sir Edward Appleton, who in a paper before this Society said, "I do not believe that you can make a valid distinction between what is called pure and applied research or rate one or other the loftier form of human activity".

There is next a segregation of the various fields of endeavour which are in most cases directed by an Associate Research Manager. Thus we endeavour to keep the different fields associated and yet preserve all the separateness which is necessary for the work to be under no disadvantage. An exercise in degrees of freedom.

The fields are :

Dyestuffs,
Intermediates,

and each of these is divided into a speculative group which, within its precise chemical territory, has a roving commission :

Polymers,
Plant and Operating Research,
Physical Chemical,
Analytical Methods,
Experimental Plant.

The unit of organisation is the chemist or his equivalent ; and each of these fields of work are broken down into Sections and further still into Groups which are multiples of the chemist unit. We have, therefore, below the rank of Associate Research

Manager, the position of Section Leader and Group Leader. The numerical size of both Groups and Sections varies according to the extent of the field they cover, and may also vary at different periods depending upon the needs of the different researches at some particular time. The size of Sections varies from 8 to 15; and the size of Groups from 1 to 4. I do not claim that these are necessarily ideal but in our experience they represent eminently suitable commands. Any research organisation apart from its scientific strength requires, like an army or other collection of persons for a common purpose, to be assisted, sustained, and nourished. First, since it is a research organisation comes this matter of assistance. What in fact is the appropriate number of trained technical assistants which the chemist (or his counterpart) requires? There is, of course no one rule in this matter. But in general we have come to the practice of one fully trained assistant for each chemist or his equivalent. We have tried most systems. There is a view that it is a good plan for one researcher to have a goodly number of assistants since it is economic of high-grade manpower; there is, too, the system which regards the experimental work as but the personal work of the researcher himself and that no part of it can be delegated without penalty. I have given you our preferred general practice and believe that this best accomplishes what Lord Moulton referred to when he said, "Nature always answers the question asked but rarely in the way that you expect". The informed and receptive eye must be ever present.

In the main, the laboratories which comprise the organisation which is the subject of my lecture are at Blackley which, as you know, lies some 3½ miles in a North North-Easterly direction from this hall. But there are laboratories exclusively devoted to research at Huddersfield, where lies the largest works operated by the Division; at Grangemouth, near Edinburgh; at Trafford Park. We have not liked the idea of a works of any size without a research department as its immediate neighbour, believing that, as research is a fundamental part of the industrial pattern, it is of capital importance to avoid any hiatus which might be construed as ocular evidence of the remote separateness of the research tool. If it indeed be true, as I believe, that there is

within industry arising out of its very nature a power to direct research, then it is vital to have a full and adequate integration into the pattern. And such evidence of this that greets the eye it is well to have. As you may well imagine, the dyestuffs industry is, more completely than perhaps any other, the organic chemist's industry ; and as the ideal type of housing for chemists within industry is the laboratory, it is natural that much thought, and it is only fair to confess much professional disagreement, has been given to the design of this type of accommodation. The discussions over the years have varied from relatively simple problems to latterly more complicated topics. Years ago as I recall it, the contest was between those who insisted that laboratories should be invariably single storey buildings and those who maintained the argument for two-storey buildings. It was claimed for the first party that important problems of drains could only be solved satisfactorily by the use of single storey buildings. Moreover, with this type of construction, there could be roof lighting and this could be made equable throughout the day by arranging for the roof to be of the weaving shed type with the glazed portion only facing North. It seems rather an idle controversy to-day, but it did at all events generate some heat and apparently no light so that it has from this point of view if from no other contributed something to the science of physics ! Since that time we have built many laboratories ; and of all types. Our largest and of this size most recent laboratories were designed by Mendeleff and Chermayeff, and the new ones we plan to build as early in the future as may be will be substantially to the latter's design, although the details will be much changed. I think our conclusions after long experience are that there is no such thing as an ideal chemical laboratory ; there are many features which are desirable but few which are decisive. And it leads to the reflection, which appears to have been true in all ages, namely, that the supreme master of his art or craft has been relatively independent of his tools. Laboratories are hallowed not so much by the architect who designed them or the builder who built them, but by the quality and importance of the work that is carried out within their walls.

The dyestuffs industry has to carry out long chemical journeys. It begins with such raw materials as naphthalene, anthracene, benzene, toluene, which are derived from coal tar. As a rule the various chemical compounds next in complexity to these are still a long way from being the components which in combination with other similar products produce a dyestuff. The chemical journey must still continue. Whilst there are, of course, exceptions the majority of these substances are only required by the dyestuffs industry and they have no other utility except for the purpose of producing dyestuffs. It is this special feature which has made it a necessity for any Research Department to have also at its disposal an experimental plant. Such a plant fulfils two functions ; it provides a supply of material for further investigation and it also provides an opportunity for working out with essential practical details a suitable manufacturing process upon which the design of a full scale plant may be well based.

There is, too, an intermediary stage and that is some place where, still in pursuit of more adequate quantities of material than are easily made in a laboratory, substances can be made not in flasks or beakers but in pots and pans and the like. In fact a chemical kitchen and so, in fact, did the German chemist refer to it.

Other necessary enabling facilities are the equipment and personnel for glass-blowing, since it is an immeasurable advantage to have the skill of the glass-blower available and at close hand to the need of the experimenter. In this way the design of special apparatus results from the joint effort of two kinds of persons ; the experimentalist and the craftsman. And the result of this neighbourliness is beneficial to both.

Precisely similar reasons underlie the provision of a small but adequately equipped instrument shop. It is as well if this instrument shop is as far as possible free of all duty to other departments since only by this means does it develop its capacity to act quickly and to accept the trial and error atmosphere that is normal in an experimental atmosphere.

Those of you who have followed my story, will have realised that to leave an industrial research organisation minus a Patent Department would be either leaving difficult problems to be resolved by external aid or courting a spirit of generosity likely not only to be unique in the industrial world, but curiously and unnecessarily altruistic. The Patent Department is staffed with technical people; chemists in fact. Mr. C. H. Hollins, now retired, laid the first foundation of the department and for some years the great knowledge and experience of Dr. Ehrhardt was at our service. Our reason for treating the matter of patents as largely a technical duty is that organised thus such a department can be of immense assistance to the progress of a research. Its detailed knowledge of the chemical literature and its regard for evidence can well be and usually is a stimulating influence. Everything that provokes enquiry and thought are appropriate surroundings for a research enterprise. After all, some ideas lie deep in " the forests of the mind ".

One other mattei which whilst not a part of the Research Department proper, it is convenient to mention at this point, especially as being part of the pattern, it is also contained in the integrated research organisation. New discoveries commonly require different techniques for their appropriate applications. The capacity to evaluate the importance of the range of utility of any discovery normally requires much research. The power to render technical service to industry is at its highest level only based upon continuous research work.

This function insofar as it applies to dyestuffs, textiles generally, and including also detergents, is carried out by the department called " THE DYEHOUSE DEPARTMENT ". Frankly this title is perhaps misleading, but this it has been called over the years so that in a way it has a tradition behind it which we should not care to alter. Besides, it would be difficult to find a really apt descriptive name for a department that has so varied a remit.

The others are the RUBBER SERVICE LABORATORY: THE RESINS SERVICE LABORATORY AND MISCELLANEOUS CHEMICALS SERVICE LABORATORY. Here, too, it is convenient to mention the BIOLOGICAL LABORATORIES at Blackley; the

EXPERIMENTAL LABORATORY at Stamford Lodge, Wilmslow, where we provide for experiments on animals other than small animals such as mice, rats, rabbits. Lastly there is the PHARMACEUTICAL RESEARCH LABORATORY, which completes the list. All be it understood research organisations in their own right.

The science of organic chemistry aided immensely by the German Chemical Industry, grew and prospered in German Universities. In consequence of this there was a procession of graduates from this country to Germany seeking research experience in German Universities. In this country there were but two Universities with schools of organic chemistry, viz., Manchester under Professor W. H. Perkin, and Leeds with Professor A. G. Perkin. There was, of course, Professor F. S. Kipping at Nottingham, and H. E. Armstrong at Finsbury College. As a consequence of this, much chemical personnel in the industry was of German nationality seeking experience and maybe a more intimate knowledge of the English language, and thus, too, it was that in the first renascence period of the Dyestuffs Industry much of the chemical talent came from the Universities of Manchester and Leeds.

Times have, however, much changed and there is now wide variety and all Universities have a school of organic chemistry. The scope of the adventure has, moreover, increased and other sciences have become partners in the effort. If figures interest you then here they are : At present the department includes graduates from seventeen British Universities ; and if you count the colleges of London and Durham's University as separate entities, the figure becomes twenty-four. It is proper that you should wish to have some numerical expression of the personnel engaged within the Research Department. Here it is, broken down into the different sciences :—

Organic chemists	221
Physical chemists	32
Physicists	10
Biologists	10
Pharmacists	10
Chemical Engineers	6
Technical Assistants	665
Miscellaneous	58
	1,012

The total figure of 289 for scientific staff should also be considered in relation to the scientific personnel in such related departments as "The Dyehouse"; the "Rubber Service Department"; the "Resins Service Department"; and the "Miscellaneous Chemicals Service Department" which together equals 126. All these figures are absorbed into the total scientifically trained population of the Division which is just over 800 of which 710 are chemists, and 123 Engineers and Chemical Engineers.

The regular, systematic and adequate documentation of both science and technology are necessary for their further progress. And for this documentation there exists the various and appropriate scientific and technical journals which are run and maintained by the Scientific and Technical Societies. Caro, the great German chemist, for whom as much as for any individual can be claimed the great development of the German Chemical Industry, referred to such journals as "swift messengers of the latest progress". You ought perhaps to know that he reserved a severe negative benediction for those people who neglected to read these journals. In my belief it is a mistake to exclude from this essential documentation of technology the published patent specifications. Fundamentally a patent is a legal contract whereby one party—the inventor—receives a monopoly over a defined period of time in return for undertaking to describe a new and novel art to the citizens of the Realm. It is the patent specification which describes the manner in detail in which the novel art is to be performed. These patent specifications constitute therefore in effect an excellent textbook in great detail of the current progress in technology. It is therefore a matter of some importance that this so to speak currency of technological development should be sustained by an organisation and persons able to mint this current coin of progress.

I have troubled to look up the record and I find that in a period of slightly less than six years, viz., 1942—1947 (in part) there have been no fewer than some three hundred papers distributed over twenty-five journals, the list of which include such variety (as one would expect, of course) as the Journal of the Chemical Society; Proceedings of the Royal Society;

Transactions of the Faraday Society; the Annals of Tropical Medicine and Parasitology; Journal of the Society of Dyers and Colourists; Journal of the Society of Chemical Industry.

Within approximately the same period, the documentation has been further amplified by the publication of 385 Patent Specifications. One of your members and a colleague of mine, Mr. W. A. Silvester, has calculated that there are over three quarters of a million pages of chemistry in Liebig's Annalen, the Berichte, and the Journal of the Chemical Society. If one adds in the more specialised journals the figure climbs to about eight millions. If also we add in the printed specifications of patents taken out in the various countries, the mass of knowledge becomes astonishingly great. Such than is the text book of chemistry, and that is only the present edition, for in normal times it received an abundant addition each year. And the other sciences are equally at our disposal.

It used to be the practice to conclude a paper in the scientific literature with an acknowledgment of permission to publish. So far as my company is concerned this policy has been changed and for some time now the practice has been merely to name the laboratories in which the work has been carried out. This is a recognition of the fact that documentation is a necessary factor in the spread of progress and that in the long run all stand to benefit by publication.

It is agreed, I think, in these enlightened days that research within industry is a continuous function and it is therefore a necessity for its abiding power that it should over a period by its results donate to the industrial pattern of which it forms a part, an earning capacity much in excess of its own expense. Only in this manner can it survive as part of the pattern. It so to speak, exists in the present by means of its rewards in the future. This account, therefore, would be failing in its purpose if it neglected to pick out some of the outstanding discoveries which have resulted.

First there is in September, 1921, the discovery of CALEDON JADE GREEN, by Davies, Fraser Thompson, and Thomas.

With natural dyestuffs and so up to late Victorian times it was impossible for the dyer, especially a textile printer, to be on all fours with the painter of pictures; the reason being that the range of shades obtainable on cotton, wool, natural silk, etc., was limited because not all dyes would dye all fibres and it was still more limited if the shades obtainable were all to be equally proof against fading. Already before 1921 there were many synthetic dyestuffs capable of giving shades on cotton which did not fade, but there were gaps in this range, particularly one for bright green shades. It was this gap which the discovery of Jade Green closed. In part the discovery was surprising. Scientific theory led to the hope of a faster blue but the particular green shade was quite unexpected. Caledon Jade Green has found a use throughout the world for the dyeing and printing of soft furnishings, and bookbinders cloth especially.

Shortly after what the Americans call World War I, and arising to some extent from earlier work in connection with dope for aeroplanes, there was developed a new artificial fibre. This consisted of Cellulose Acetate and was first put on the market as "Celanese". Amongst its excellent and desirable properties this new fibre had at the time we speak of a serious disadvantage in that, like most other fibres have it had no natural appetite—what the dyer calls affinity—for the usual ranges of dyestuffs. It could only be dyed with the greatest difficulty; and for a textile fibre that is a most serious drawback. It so happened, however, that there was a class of compounds which whilst not dyestuffs for any other purpose; not even dyestuffs "within the meaning of the Act", nevertheless dyed Cellulose Acetate admirably. The discovery that this class of compounds had this property was made by Baddiley and Shepherdson in Blackley in March, 1923. Thus there was as a result of this discovery an almost complete range of shades available for this new fibre.

I have spoken earlier of fastness to light of Caledon Jade Green. The class of dyestuffs of which this dyestuff is a member are all characterised by great resistance to fading by the action of light. This class is usually known as Anthraquinone Vat dyestuffs. They are compounds which are insoluble in water

and, therefore, required a special process of dyeing. Vat dyestuffs would possess a great additional advantage if they could be rendered soluble in water. The problem was first solved by a firm in Switzerland, Durand and Huguenin. A different process of rendering these products soluble in water was discovered in Grangemouth by Harris, Jones, Wylam, and to this process was given the name of Soledon reaction. This discovery was the fruit then of what is best described as closely competitive research ; in inception it represented our successful attempt to keep abreast of an important development in Switzerland, but wider possibilities opened out and Soledon Blue R.C. was discovered by Fairweather and Thomas in Grangemouth five years later. Here was a new field of endeavour to which there was intense effort directed in this country, in Germany, and in Switzerland. Nevertheless five years elapsed before the second discovery. There is much talk nowadays of the delay between the first discovery which opens up a new field and the subsequent ones. One gathers that it is all to be altered in the future. I suggest for your consideration that in this creative act, as in other examples of creation, there may exist a period of gestation which is deliberately shortened only at great peril.

The next example in order of time is at the periphery of the dyestuffs field. What may be termed the tide of Plastics research was in full flood in the early 1930's. One effect of this flood tide is that for the past few years the general public have taken up the term " Plastics " as a kind of universal wonder. Everything is made from Plastics. It recalls to me a comment made by Sydney Smith in another connection, " Everything was new, everything was true, and everything was immensely important ". Anyhow, as part of this great interest in new plastic, Rowland Hill in November, 1931, at Blackley, first studied the substance methyl methacrylate and its polymer in detail and began to appreciate its possibilities. Colourless transparent substances could already be made, but this new substance was colourless, transparent, rigid, workable, durable and thermoplastic ; but in addition it had excellent optical properties. At first we called it " Resin M ", but before it came on the market it was (more

appropriately) christened Perspex. Perspex is known to all of you for its uses in pilot's cabins, observation domes and windows in aircraft, and it has throughout the civilised world found this and other uses, e.g. in artificial dentures, optical lenses and art objects of all kinds. Perspex is a polymerised form of methyl methacrylate and the length of the polymer chain varies from 500 to 3,000 of these units depending upon whether the polymer is granular or cast. It is the outstanding balance of chemical, mechanical and optical properties which has rendered Perspex pre-eminent amongst transparent plastics. It is tough enough to withstand rough usage down to the lowest temperature encountered by aircraft. In common with almost all plastics it absorbs a small amount of water but unlike the majority it is unaffected in appearance, dimensions and physical properties by the absorbed moisture. It is colourless and remains so after years of exposure to sun and rain. One disadvantage Perspex has is that like so many plastics it lacks resistance to abrasion. Its perfect optical clarity allows every faint scratch to be seen in sharp relief when viewed at the correct angle. Nevertheless superficial scratches are early removed by polishing.

Use has been made of the high transparency of Perspex in so to speak "piping" light round bends. Light is admitted at one end of a bent rod or tube and transmitted through the substance to the other end. The curves of the light source are arranged so that the light is totally internally reflected and kept inside the rod or tube until it reaches the desired point. Such devices are used by dentists for illuminating the interior of the mouth, or by surgeons for conducting light to the seat of intricate operations. There is a book published in the U.S.A. with the title of "The World's Great Inventions"; it records the name of Rowland Hill and Perspex.

Fundamentally the organic chemist in his study of the relation of chemical constitution to physical properties is a designer and erector of buildings appropriate for particular purposes. He is therefore just as much concerned with problems of shape and size, of stresses and strains, of angles and dimensions, as the architect proper; there are, too, both beauty and inspiration in such structures for those capable of appreciating the

science. Moreover, the " buildings " of organic chemistry are in principle, though more rarely in practice, erected from elementary units just as the builder lays brick by brick. This planned and deliberate synthesis of molecules is characteristic of organic chemistry, in distinction from inorganic chemistry.

The organic chemist in the practice of molecular architecture has given a particular name to those parts of the edifice which introduce the characteristic of colour ; he calls them chromophores. A coloured substance is not necessarily a dyestuff—the latter results from the addition to the structure of certain other groupings in addition to the chromogenic part of the molecule—but alike for colour and for dyeing power the prime necessity is the chromophore.

The suggestion that the presence of chromophores within the molecule is responsible for colour in an organic chemical substance is an old one and was made by Witt in 1876. Whilst its validity remains true, the passage of years showed that it was perhaps only part of the story and required an additional conception. This we owed to that revered and dynamic personality, the late H. E. Armstrong, who showed that many of the coloured substances then known had a structure similar to quinone, which itself is a pale yellow-coloured substance. That was in 1888.

Recent work has added a further refinement in that whilst this chain of stresses preserves a sequence of " stress " and " no stress ", the particular incidence of any stress is not constant but oscillates and gives rise to what is called resonance. Actually the theory assumes an intermediate stage between the two changes as being the really effective state, much as a journey may start at *A* and finish at *B* and the rate of the journey be so incalculably swift that no traveller has ever seen the intermediate places which lie between the terminal points.

The number of coloured organic chemical products is extremely great ; the number of possible dyestuffs must run into a million or so ; and the number of dyestuffs which by reason of special properties are commercially available is probably between two and three thousand. On the other hand, the number of Chromophores is relatively much smaller. And

whilst individual dyestuffs may lose their utility and become obsolete, invention and research more than balance the wastage, so that the total number available still grows. Indeed, an increasing demand for diversity and range of dyestuffs seems to go hand in hand with the progress of civilisation. Even so, the discovery of a single new dyestuff usually ranks as an important event in both the science of organic chemistry and the technology of dyeing and printing. The discovery of a new chromophore is of course a much rarer occurrence, and always an important and exciting one, since it should open up a vast new continent. When therefore the chemical constitution of the phthalocyanines was published in the Journal of the Chemical Society in 1934 revealed the existence of a new chromophore, the interest aroused was both natural and widespread.

I shall come in a moment to the manner and account of this discovery. But we must continue our present theme.

This new chromophore fits with precision into the modern conception of colour and affords a splendid example of resonance. Although the existence of the phthalocyanines was not predicted, and was not perhaps even predictable, yet now the discovery has been made and the structure of the molecule ascertained, no one can fail to remark the inevitability of the compound.

Phthalocyanines, themselves entirely products of the chemist's skill, have resemblances of two important substances which occur abundantly in nature. The first is chlorophyll, which is the green colouring matter in plants; and the second is hæmin, which is the red colouring matter in blood. Both of these play an important part in the cycle of life in the two kingdoms, vegetable and animal, in which they are respectively so widespread. Whether this relationship implies any profound physiological properties for future members of the phthalocyanine series cannot be foreseen, and must await further scientific exploration. Both chlorophyll and hæmin, however, are highly sensitive substances easily destroyed by light, heat, and even mild chemical reagents. Phthalocyanines, on the other hand, withstand the action of light and are amongst the "fastest to

light" substances known. They resist heat so well that the copper compound will sublime at about 600° C. without decomposition, a property which in itself is sufficiently remarkable to render the phthalocyanines unique in this respect among organic compounds.

The phthalocyanines possess a further property which admirably adapts them for the special printing ink required for the so-called three-colour process used in colour printing. This in essence consists in making three printing plates, prepared by photographing the picture to be reproduced through selective colour filters in turn. Such plates are capable of printing as single images all the yellow, all the red, and all the blue portions of the picture. If prints are made from each of these plates (due care being paid to proper coincidence of the three images) so that each printing is superimposed—first the yellow, next the red, and finally the blue—a reproduction in full colour of the original picture results. It is essential that the yellow, the red, and the blue inks used shall be as nearly pure yellow, pure red, and pure blue as possible. If, for example, the yellow is an orange, that is yellow plus red, or a greenish yellow, that is yellow plus blue, or if the blue is a purple blue, that is blue plus red, then these secondary and adventitious shades are misplaced on the plates and when superimposed lead to dull reproduction.

In 1934 Haddock, Lodge and Lumsden at Blackley discovered a series of dyes for the dyeing of woollen materials which have especially bright shades and more serviceable fastness than was before available. The chemical solution of this problem can be indicated by saying that whereas the colour of any one dyestuff of this series of Carbolan Dyestuffs was approximately predictable before it was made, as a new chemical compound, yet the behaviour on the dyed woollen material (e.g. its light and washing fastness) could not be exactly predicted. Additional chemical complexity had been introduced in the form of what may be called expected fixatives. The choice of what to transfer to the works, out of a multitude of laboratory products, then depended upon the confirmation, by selective comparative testing, of the expectations.

I should mention the discovery of "Paludrine" (Rose, Davey and Curd), a new and novel specific for the cure and prevention of malaria, the great promise of which seems to be fulfilled. As some of you may know, the presence of large bodies of troops in Africa, in India and the Far East, made malaria one of the great problems of the war. In consequence of this my Company became a large producer of Mepacrine, which at that period was the best-known remedy against malaria. This fact gave us a great urge not only to improve and refine the technique of manufacture of Mepacrine but to try and discover improved products for this task. It was as a result of this urge that we discovered Paludrine. My reason for telling you all this is as some proof of the statement I made earlier that research had become part of the so-to-speak daily pattern of the Dyestuffs Industry, and that even in the distraction of a war with new tasks undertaken, the pattern still held together and in this holding together had the same expected response.

I have already referred to the new chromophore associated with the blue shade of copper phthalocyanine which was a major event in tinctorial science. The limited applicability of the phthalocyanine structures in dyeing and printing textiles was a challenge not to be ignored by the research chemist and great efforts were directed towards the discovery of methods for the conversion of the water insoluble pigment Monastral Fast Blue B into a dyestuff which could be applied alongside other textile dyestuffs. The initial task was to render the pigment soluble in water so that it could as a solution be absorbed by textile fibres.

To produce a permanent colouration it was than necessary to remove the chemical groups giving solubility to the structure. This simple concept took some ten years before it was translated into reality. The product of the research was Alcian Blue 8GSd., a textile dyestuff yielding turquoise blue shades unsurpassed in their combination of brilliance and fastness. Nor was this all, the technological researches into Alcian Blue 8GSd., revealed its especial suitability for application by textile printing techniques and demonstrated that a new method for the application of coloured compound to textile fibres has been evolved. The names associated with this discovery are Haddock and Wood.

Excellent trichromatic yellow and red pigments have existed for some time, but the full beauty of reproduction theoretically possible by the use of the three-colour process could not be realised in practice by the use of ink based on existing blue pigments. The discovery of the phthalocyanines removed the remaining flaw in this method of colour reproduction, and as a result the Monastral colours were placed on the market.

The phthalocyanines have, of course, all the range of utility of which pigments as a class can be employed. The only two blue pigments previously available with the characteristic of exceptional fastness to the action of light were Ultramarine and Prussian Blue, both well remembered by everybody as inhabitants of the box of paints of childhood days. Both have, however, serious shortcomings from which the copper phthalocyanine does not suffer. Prussian Blue is unfortunately damaged by alkalis and Ultramarine by acids.

The story of the discovery and the patient and skilful unravelling of the structure of the phthalocyanines is a splendid emblem of the happy marriage which has existed between the pure science of organic chemistry and the technology of the British dyestuffs industry, a union whereby a full and abiding partnership in observation and research can make invention a continuing reward.

The first member of the series was discovered by chance in 1928. It was observed that the manufacture of phthalimide in the works at Grangemouth resulted on occasion in a number of batches being slightly discoloured and the phthalimide, therefore, was unsuitable for its proper purpose. Investigations on the spot by Dunworth and Drescher showed that the discolouration was caused by the presence of traces of a dark blue substance which was apparently formed during the reaction of molten phthalic anhydride with ammonia. The cause of this trouble having been ascertained, it was only necessary to adjust the conditions of manufacture so as to eliminate the undesirable impurity. There the matter might well have ended, but a detailed examination of the isolated impurity revealed too many marks of potential interest for the substance to be dismissed

lightly from consideration. It was very stable and crystalline, and contained iron, which was apparently firmly entrenched as part of the molecule since it was not readily eliminated by the customary means. Moreover, and more important, it was a dark blue substance, and perhaps this was safeguard enough and to spare, in a dyestuffs works at any rate, against any tendency to allow such a substance to escape further and closer examination. The fact that it was coloured and insoluble in water obviously suggested its use as a pigment, but despite much experimentation and consideration nothing of utility resulted. A tribute is therefore merited to the people concerned, who despite the early lack of promise had sufficient faith and interest in this novel substance to pursue the matter further. We had some years earlier come to the conclusion as the dyestuffs industry lay on the threshold of the science of organic chemistry, we should have close relations with our academic neighbours. It was, we thought, necessary for our mutual benefit. After all, some of their students were our "new entry". And we were ourselves both by discovery and by new reactions extending the science of organic chemistry. To this end, we invited Sir Jocelyn Thorpe, Professor (now Sir Robert) Robinson, and Professor Heilbron (now Sir Ian) to become consultants, which they did, and the latter two still are. We have since extended the number of consultants. Our belief that if we could establish the right relationship, it would be of lasting benefit to all concerned has been realised. The word "Consultant" in this connection is not really the most suitable word, but it is the best we have so far found. This word rather implies a retainer in the sense of an exclusive use; this is not our purpose. Nor in fact is there any responsibility for any part of our work. It is really an arrangement whereby both parties can discuss a science in which there is a common interest without damage to either's interests. I have referred to this scientific companionship in order to give you a concrete example of the manner in which it works. At our suggestion, Dr. Linstead of the Imperial College of Science and Technology, London, took up the scientific study of the compound. To him also we owe the name which signifies both the original and deep blue colour.

The problem of the chemical constitution of the Phthalocyanines was solved by Linstead and his co-workers, and was reported in the Journal of the Chemical Society in May, 1934.

It is my thesis that the Research Organisation about which I have given you some account has one special feature, in that it has grown to its present dimensions and character in response to the urge and need which are manifest within an industry. The vicissitudes it has experienced and the changes to which over the times it has been subjected, were in fact part of the shaping process by which it reached its present balance. There exists, I believe, within the industrial pattern a latent power of direction which with most beneficial results can be realised and used in experimental research. It is the inherent opportunity which arises specifically through the nature of the repeatable experiment which we otherwise call industry. But to realise it there must be the necessary degrees of freedom. Thus there has been no formal design; no set plan over a period; no rigidly laid down distant objectives. But there has been a natural and free growth within the leavening influence of the industrial pattern. That has in fact been the lodestar. Nor is this free growth to a pattern without parallel in other human affairs. It is in fact a characteristic of the constitutional history of modern Britain. Lindsay Keir in his book on this subject says:

> " Continuity has been the dominant characteristic in the development of English Government. Its institutions although unprotected by the fundamental or organic laws which safeguard the 'rigid' constitutions of most other states have preserved the same general appearance throughout their history, and have been regulated by principles which can be regarded as constant. . . . "

Yet continuity has not meant changelessness. Ancient institutions have been ceaselessly adapted to meet purposes often very different from those for which they were originally intended and have been combined in apparent harmony.

May be in this matter you dislike historical analogies. How then will this do, which I take from D'Arcy Thompson's Introduction to his " Growth and Form ":

> " The form then of any portion of matter whether it be living or dead and the change of form which are apparent

> in its movements and its growth may in all cases alike be described as due to the action of force, in short the form of an object is a 'diagram of forces' in this sense at least that from it we can judge of and deduce the forces that are acting or have acted upon it."

Thus it is that I believe given suitable laboratories and equipment a collection of able and appropriate scientific people exposed to the inherent forces which lie within the periphery of an industry will become an effective and abidingly maintained research organisation. One further characteristic will be attained. Lord Morley in his "Essay on Compromise" expresses it better than I shall. Listen therefore to him:

> "The right of thinking freely and acting independently, of using our minds without excessive awe of authority and shaping our lives without unquestioning obedience to custom, is now a finally accepted principle in some sense or other with every school of thought that has the smallest chance of commanding a future."

Kenneth Mees, of the Eastman Kodak Company, on this point you may find even more appealing: "No Director", he says, "who is any good ever really directs research—what he does is to protect the research men from the people who want to direct them".

I set out to recount the story without forbearing to annotate with my own beliefs in passing of a research adventure within an industrial pattern; and in conclusion would leave you with a remark for the future by Professor Meldola to the Society of Arts in 1886. He was discussing, as was the vogue in England in that period, the immensely greater development of the dyestuffs industry in Germany in comparison with the chequered state of the industry in Great Britain: "The strength of our competitors lies in their laboratories". What was true in 1886 is equally true to-day.

Some Campanian Vases in Manchester

By ALEXANDER CAMBITOGLOU, M.A.

(Communicated by Professor T. B. L. Webster.)

NECK-AMPHORA M.M. IVE 28[1] Pl.I.

Height 0·27 cm. Diam. 0·13 cm. Provenance unknown. Pink coloured clay, covered with miltos on the reserved surfaces of the body and neck. The glaze is black and bright. On both sides of the neck a female head, between scroll on the left and reserved circle on the right, wearing kekryphalos. The head on (A) is more elaborately decorated than the one on (B). Above the head egg-pattern with intermediate black dots. On the shoulder tongue-pattern with intermediate double vertical lines.

(A) A bearded satyr setting his right foot on a rock (dotted with black and white-yellow spots) and holding a "phiale rabdote" in his left with a row of yellow dots above its rim. His right forearm rests on his right knee, his head is decorated with a white-yellow wreath and his chest with two similar crossed wreaths; there are white-yellow bracelets round his wrists.

(B) A mantled youth wearing white-yellow diadem with a decorative row of beads above it; the lower edge of his mantle is decorated with a row of black dots; in its centre there is a small circular ornament.

Beneath (A), (B) and floral ornament a pattern of stylised black waves to the right.

The floral ornament under the handles consists of a palmette flanked by scrolls, which end in campanula flowers. The foot, handles, and mouth are moulded. The surface beneath the foot is decorated with a dark circular band.

Cf. Capua 7543 (P.19), from Capua. *C.V.* IV, Er pl. 25, 1—3.
Capua 7542 (P.20), from Capua. *C.V.* IV, Er pl. 28, 1—3.

It is obvious that the style of the Manchester vase has many common points with that of Capua 7543 and Capua 7542[2]. The

1. The abbreviation M.M. is used instead of Manchester Museum.

2. The two Capua vases are known to me only by their reproductions in the Corpus Vasorum.

neck-amphora Capua 7543 has very similar decoration on neck and shoulder; the floral ornament is almost identical. With the bail-amphora Capua 7542 the Manchester vase is connected through the tongue-pattern on the shoulder, the floral ornament and the wrapped youth on the reverse. Common to the three vases is the stylised wave-pattern and the shape which would suggest a rather early date within the whole Campanian style, that is round or just before the middle of the fourth century.[1]

BELL-KRATER M.M. IVE 17, Pl. II AND SKYPHOS M.M. IVE 16, Pl. III.

Bell-krater M.M. IVE 17: Height 0·18½ cm. Diameter 0·18 cm. Provenance unknown. Pink-buff coloured clay, covered with miltos on the reserved surfaces of the body. The glaze is brown-green, the foot broken and restored. Beneath the mouth a dark laurel-pattern to the left, not extending behind the handles.

(A) On the left a male head with white diadem; on the right a female head wearing "sakkos", white diadem and ear-ring, and brown necklace consisting of a row of beads hanging from a curved line above it. The two heads face one another. In the background a reserved phiale with white centre and periphery, also a leaf.

(B) Lion with lifted tail jumping to the left.

Beneath (A), (B) and floral ornament a pattern of vertical strokes. Beneath each handle a palmette flanked by two vertical leaves.

Cf. Capua, from Capua. *C.V.* IV, Er pl. 36, 4–5 and Capua, from Capua. *C.V.* IV, Er pl. 36, 7–8; also Once Frignano Piccolo, Maglione, from Frignano Piccolo. A, *NSc.* 1937, 105, X.

Skyphos M.M. IVE 16: Height 0·15½ cm. Diameter 0·14 cm. Provenance unknown. Pink-buff coloured clay with miltos on the reserved surfaces of the body. The colour of the glaze varies from brown to brown-green. One handle is broken and restored. The surfaces on and round the bases of the handles are reserved; so is the surface beneath the foot.

1. Madrid 11235, attributed by Professor Trendall to the Asteas Group (*Paestan Pottery*, pl. XIVb) has a rather corresponding shape.

(A) Female figure walking to the left. She is dressed in an unsleeved chiton (which is girdled) with a kolpos falling down to the knees. She wears a " sakkos " (decorated with a white-yellow wreath), white-yellow ear-ring, beaded necklace, and bracelet. She holds a mirror in her right and a wreath in her left hand, both of white-yellow colour. In the background a reserved disc with white-yellow periphery.

(B) A wrapped youth facing to the left. The upper border of his mantle is embattled ; his hair is decorated with a white-yellow band. In the background two reserved discs with white-yellow peripheries.

Beneath (A), (B) and floral ornament a pattern of stylised waves to the right. Beneath each handle a palmette, flanked by two scrolls ending in rhomboid flowers, two sides of which are painted with white-yellow colour.

Cf. Musée Rodin, inv. T.C. 613, *C.V.* pl. 38, 1–2 ; the reverse of Capua, from Capua. *C.V.* IV, Er pl. 36, 4–5 ; Once Frignano Piccolo, Maglione, from Frignano Piccolo. A, *NSc.* 1937, 105, XI ; Sèvres 53, from Basilicata. *C.V.* pl. 38, 21 and 23.

The bell-krater M.M. IVE 17 and the skyphos M.M. IVE 16 appear together in this article because, in spite of the obvious differences of their style, they are both connected with the group of Campanian vases, which in Sir John Beazley's publication " Groups of Campanian Red-Figure "[1] are put together under the title : " The Painter of Capua PLL. 11—13 ".[2]

The first vase can be classified with the three bell-kraters which belong to this series. Its shape is not unlike that of two of the bell-kraters of this group[3] and the lion which is represented on its reverse can be stylistically connected with those on Nos. 2 and 3 in Beazley's list.[4] The floral ornament on the Manchester bell-krater is not different from that on the second bell-krater which has been attributed to the style of

1. *J.H.S.* 1943, 66—111.

2. *Op. cit.*, 71—72.

3. I.e. Capua, from Capua *C.V.* IV, Er. pl. 36, 4–5 and Once Frignano Piccolo, Maglione, from Frignano Piccolo. A, *NSc.* 1937, 105, X.

4. With the lion on the vase No. 2 as far as treatment of mane is concerned ; with that on the vase No. 3 as far as attitude is concerned.

Capua PLL. 11—13[1] and its laurel-pattern, which is not reserved but painted on a reserved background, appears just the same on the third bell-krater of this group.[2]

The skyphos M.M. IVE 16 can also be connected with the style of the vases of the Capua PLL. 11—13 group. A sort of parallel I can find for it is the skyphos Musée Rodin, inv. T.C. 613, *C.V.* pl. 38, 1–2.[3] The Musée Rodin skyphos is a more careful work ; its shape is slightly finer and the figures on both its sides lack the coarseness of those on the Manchester skyphos. The subject is similar on both vases with the difference that the woman on the obverse of the Manchester skyphos is standing while that on the obverse of the Musée Rodin vase is seated, and that the wrapped youth on the reverse of the latter is holding a small branch while that on the reverse of the former is not.[4] Similar on both vases is the treatment of the floral ornament, with the difference that the campanula flower takes the shape of a rhombos only once on the Musée Rodin skyphos. Common to both vases is the stylised wave-pattern beaneath (A), (B) and floral ornament.

The motif of a woman holding a mirror and a wreath brings us near the group of Capua PLL. 11—13.[5] Compare for instance the subject on the obverse of the bail-amphora Sèvres 53, from Basilicata. *C.V.* pl. 38, 21 and 23, attributed by Beazley to this group. The reverses of the Manchester and Rodin vases can be compared with those of the Sèvres bail-amphora, the bail-amphora Capua 20, from Capua *C.V.* IV, Er pl. 29, 5–6 and the bail-krater Capua, from Capua, *C.V.* IV, Er pl. 36, 4–5.[6]

1. I.e. Capua, from Capua, *C.V.* IV, Er. pl. 36, 7–8.
2. I.e. Once Frignano Piccolo, Maglione, from Frignano Piccolo. A, *NSc.* 1937, 105, X.
3. This vase is not included in Beazley's list of the Capua pll. 11—13 group ; it seemed to me however that its general character places it here.
4. Other stylistic differences between the two vases can be found in the treatment of faces, dresses and shoes.
5. This motif is characteristic for this group though it appears occasionally on other Campanian vases : *cf.* the skyphos London F255, from Avella (?) *C.V.* IV, Ea. pl. 6, 1 ; the bell-krater once Treben, Leesen. A, *Kat. Leesen* pl. 4, 48, whence *J.H.S.* 1943, 81, fig. 8.
6. For the treatment of the wrapped youth on vases of some other Campanian groups *cf.* Capua, from Capua. *C.V.* IV, Er. pl. 32, 4 and 6 ; Capua 7549 (P. 46), from Capua. *C.V.* IV Er. pl. 41, 1, pl. 42, 10, pl. 44, 2.

The group of Capua PLL. 11—13 and the three vases which have just been connected with it could perhaps be dated still before the middle of the fourth Century.

THE HORSFALL MUSEUM CUP Cat. No. 93, Pl. IV, 1–2 ;
THE SQUAT LEKYTHOS M.M. IVE 10, Pl. V, 1.

The Horsfall Cup : Height (from top of handles to foot) 0·06½ cm. Diameter 0·17½ cm. Acquired in 1918. Provenance unknown. The clay is of a light pink colour, the glaze is brown, the relief line is very vigorous. The bases of the handles, the band beneath the laurel-pattern on the outside surface of the cup and the moulded transition from the body to the foot are reserved. The surface beneath the foot is reserved and decorated with three concentric dark bands and a dark centre.

(A) and (B). A laurel-pattern with berries to the right.

I. A standing warrior in ritual scene. He wears a short-sleeved chiton with a white-yellow girdle round his waist and a white-yellow wreath round his hair. He holds a skyphos (white with yellow ring round the rim and the transition from body to foot) in his right hand, leans his left on a shield (white, decorated with yellow circle) and stands before a stele (the left side is white and outlined in yellow) on which is a white object (an egg or a fruit). In the background white-yellow disc, phiale and head-band. The scene is framed by a reserved thin band and ivy-pattern with berries (some of the ivy-leaves are white, others are yellow ; the berries are white).

Cf. Oxford 445. *J.H.S.* 1943, 75, fig. 5 ; London F242, from Avella. *C.V.* IVEa pl. 9, 3 and Walters, *B.M. Cat. IV*, pl. 9, 2.

The Squat Lekythos M.M. IVE 10 : Height 0·18½ cm. Diameter 0·10 cm. Broken and restored ; a fragment near the foot is missing. Provenance unknown. The clay is pink, the glaze is brown, the relief-line is very vigorous. The surface on and round the bases of the handle are reserved ; so is the surface beneath the foot. The mouth has the shape of a funnel. On the neck there is a pattern of vertical strokes.

A woman running to the right and turning her head to the left. She holds a bird in her right and a fillet in her left hand.

She is dressed in a sleeveless chiton and her hair is decorated with a beaded wreath (which has almost disappeared). She wears white-yellow bracelets (which have also been removed). In the background a head-band, a rosette and a row of dots beneath the neck, the yellow colour of which has been removed.

Beneath the handle a palmette flanked by two scrolls ending in campanula flowers (originally decorated with white-yellow colour) and two small circles.

Cf. in style vases belonging to the AV. Group, Beazley *J.H.S.* 1943, 74—80; for the floral ornament *cf.* Sèvres 137, from Basilicata, *C.V.* pl. 38, 9 and 17.

The Horsfall cup can be attributed to the AV. Group.[1] It stands near the cup Oxford 445.[2] The next parallel is a London lekythos[3] which belongs together with the Oxford cup to that section of the AV. Group called " the Danaid painter ".[4] Beazley thought that these two vases were painted by one hand[5] to which now the Horsfall cup may be added.

The attribution of the squat lekythos M.M. IVE 10 to any well defined Campanian style seems to be more difficult. In spite of that an attentive study persuaded me that the vase can be connected with the AV. Group. An examination of the main features of this latter would be necessary at this point. As far as drapery goes the London hydria F213 is a representative piece of this style.[6] The folds have not only straight, but also semi-circular or semi-oval lines reminding one of falling drops. This kind of drop shaped folds is rarely found on vases of earlier Campanian groups.[7] The treatment of the female

1. Beazley, *op. cit.*, 74—80.

2. Beazley, *op. cit.*, 75, fig. 5. *Cf.* the treatment of the eyes, hands and joints; also the wreaths and draperies. The framing of the inside representation with an ivy-leaf pattern is common to both.

3. London F242, from Avella. Walters, *B.M. Cat. IV*, pl. 9, 2; *C.V.* IV, Ea. pl. 9, 3.

4. Beazley, *op. cit.*, 74—76.

5. Beazley, *op. cit.*, 76.

6. London F213. Passeri, pl. 293; *C.V.* IV, Ea. pl. 9, 8.

7. Drop-shaped folds has the drapery on the obverse of the situla London 1928. 7—19. 3; *B.M.Q.* 3, pl. 25, a—b, by the Parrish painter; also the hydria London F500, Walters, *B.M. Cat. IV*, pl. 14, 2; *C.V.* IV, Ea. pl. 8, 14 of the group of London F500, where they appear as almost perfect ovals or circles.

head on AV. group vases has several individual traits: the massive hair which is so common here is not found to my knowledge on earlier Campanian groups.[1] Characteristic is the decoration of the hair with a beaded wreath, as it appears on the hydria London F212, from Avella, Walters *B.M. Cat. IV*, pl. 8 ; *C.V.* IVEa pl. 4, 1, or with the sort of wreath used on the hydria Naples 869, Patroni, 108. The treatment of the face is difficult to follow ; the eyes are sketchily drawn with marked relief-lines.[2] Some details of the style are easier to follow on male figures[3] which have often very pronounced joints[4] and peculiar feet.[5] Pet birds though often met on Greek South Italian vases are more abundant in the AV. group, and exceptionally frequent with the Danaid painter. The filling ornament is very rich and consists of head-bands, dotted rosettes,[6] laurel branches,[7] scrolls,[8] hanging curved lines[9] and ivy-leaves.[10] The landscape is often designed as it appears on the shoulder of the hydria London F219.[11]

And now to our Manchester squat lekythos. Though it is not closely connected with any of the vases of the AV. group known to me, it has most of its features ; the massive hair of the female figures, the dotted wreath, the thick relief-line, the peculiar treatment of the eye, the drapery with the drop-shaped folds, the filling ornament consisting of a fillet and a dotted rosette.

1. For the usual feminine hair-dressing on earlier vases *cf.* Capua 7554 (P. 15), from Capua. *C.V.* IV, Er. pl. 22 and pl. 23, 2 ; and Capua, from Capua *C.V.* IV, Er. pll. 11—13. For the massive hair on vases of the AV. group *cf.* London F210, from Avella. *C.V.* IV, Ea. pl. 8, 15 ; London F401, from Apulia. *C.V.* IV, Ea. pl. 12, 7.

2. *Cf.* Capua, from Capua, *C.V.* IV, Er. pl. 15, 3.

3. *Cf.* The youth on the vase Oxford 445. *J.H.S.* 1943, 75, fig. 5.

4. *Cf.* Oxford 445 and the Horsfall Museum cup.

5. *Cf.* London F219, from Avella. *C.V.* IV, Ea. pl. 4, 2.

6. *Cf.* London F212, from Avella. Walters, *B.M. Cat.* IV, pl. 8 ; *C.V.* IV, Ea. pl. 4, 1.

7. *Cf.* London F194, from Nola. *C.V.* IV, Ea. pl. 10, 5.

8. *Cf.* London F254, from Avella. *C.V.* IV, Ea. pl. 6, 4.

9. *Cf.* London F236, from Avella. *C.V.* IV, Ea. pl. 11, 19.

10. *Cf.* Würzburg 874, Langlotz, pl. 250.

11. *Cf.* London F219, from Avella. *C.V.* IV, Ea. pl. 4, 2.

An influence of the Boston Orestes painter on the AV group has been long ago asserted[1]; from which it follows that the latter would correspond chronologically to the former. Trendall dated the Paestan Transition period from about 330 to 310 B.C.[2] The Boston Orestes painter would occupy the earlier part of this period, to which the two Manchester vases in question must also belong.

THE HERACLES AND HIPPOLYTE BELL-KRATER M.M. IVE 30, Pll. V, 2 and VI, 1.

Height 0·42 cm. Diameter 0·39½ cm. Provenance unknown. Buff-coloured clay. Colour of glaze varying from dark-brown to black. The vase is broken and restored. Some of the colours may be modern. The inside surface of the handles and the surface behind them are reserved, so is a band at the junction of the foot and its basis, and the surface beneath the foot. On top a laurel-pattern to the left between two reserved thin bands.

(A) Heracles represented as a youth facing to the right, with a strap slung over the right shoulder and a yellow wreath round his head. He leans on his (yellow) club from which the lion-skin is hanging. On the right Hippolyte dressed in short-sleeved short chiton and chlamys (fastened with yellow brooch), with girdle and crossed telamon slung over the shoulders (both decorated with yellow buckles). Her hat and boots are touched with yellow, her bracelets are yellow. With her right hand she offers her girdle to Heracles, with her left she holds a spear. The naked parts of her body and face are white with yellow details, so is the horse behind her. On the left is a naked youth (Iolaos) wearing a white-yellow pilos touched on top with green colour. He holds a staff in his left hand, from which a mantle is hanging. The dresses of Hippolyte and Iolaos, and the lion-skin are red. In the background white-yellow shield and phiale, two yellow discs, white-yellow ivy-leaves and dotted yellow rosettes. On the ground a row of white-yellow pebbles.

(B) Woman covered with mantle, wearing yellow diadem, ear-ring and bracelet and sitting on a rock which is framed by

1. Trendall, *Paes. Pot.* 109–10; Patroni, 111.
2. Trendall, *Op cit.* 91.


(1)


(2)


(3)

(1)

(2)

Plate II.

(1)

(2)

Plate III.

(1)

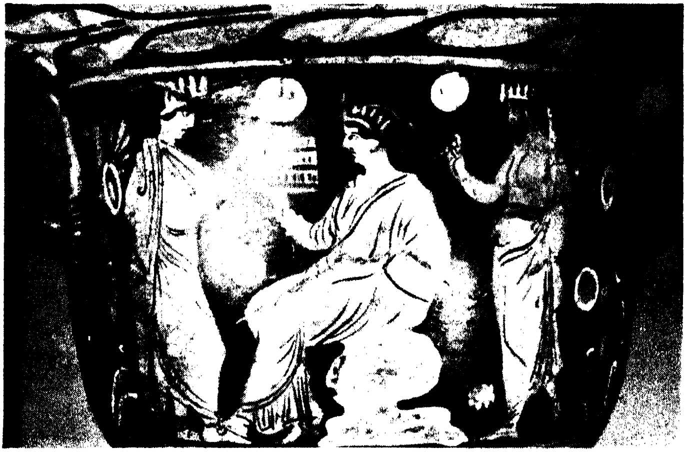
(2)

PLATE IV.

(1)

(2)

PLATE V.



(1)

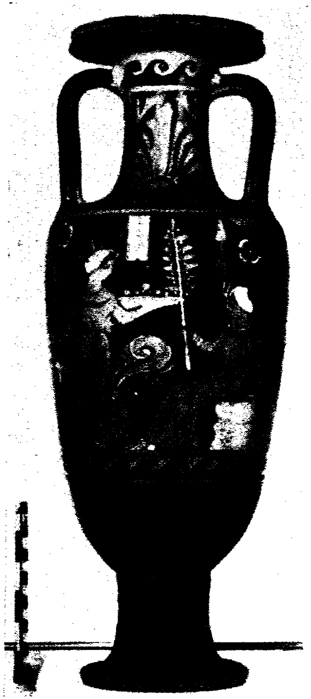
(2)

PLATE VI.

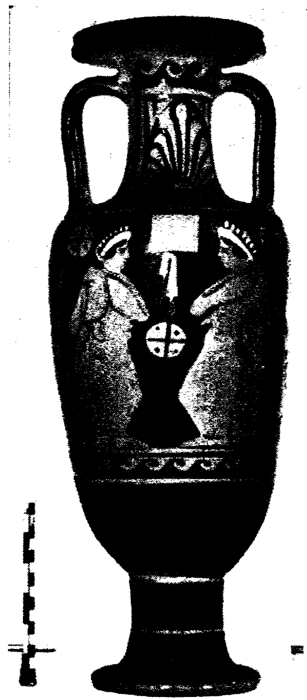

(1)


(2)


(3)



(1)



(2)

(3)

a white-yellow line and dark dots (partly modern?). On the right a bearded man wearing mantle and diadem and holding twisted yellow staff. On the left a wrapped youth wearing yellow diadem, looking at the woman who offers him a cista. In the background a pair of halteres, three phialæ and a dotted rosette all touched with yellow.

Beneath the handles palmette flanked by scrolls ending in campanula flowers. The details are white-yellow. The colour of one campanula looks modern. The scrolls on the obverse are red. Beneath (A), (B) and floral ornament a maeander pattern with intermediate saltires.

Cf. Winterthur, Museum. Bloesch, *Ant. Kunst,* pl. 49 and fig. 13; Vienna, Oest. Mus. 471, *Jh.* 18, beibl. 243; A. Pfuhl, *MuZ.*, fig. 802.

The Manchester Heracles and Hippolyte bell-krater is the most interesting vase in this series. Its closest parallel is a bell-krater in the Winterthur Museum[1]; next comes the bell-krater Vienna, Oest. Mus. 471, *Jh.* 18, beibl. 243. The three vases have striking similarities between them and seem to be by one hand.[2] The treatment of the male bodies with the soft muscles, the well pronounced relief line and the peculiar fingers is common to all of them, so is the type of wreaths and diadems.[3] The similarity extends to the filling and floral ornaments which are characteristic of this group and to the use of the same maeander-pattern beneath (A), (B) and floral ornament. Beazley attributed the Vienna bell-krater to the AV. group[4] and thought of forming a sub-group round it.[5] Though the connection between the vases of this sub-group is undeniable and the three bell-kraters with which we are concerned in this chapter belong, in a broad sense, to the style of the AV. group, we should nevertheless suggest that our three vases were produced by a separate

1. *Cf.* Bloesch, *Ant. Kunst,* pl. 49, and fig. 13. For the addition of this vase to our group I am indebted to Professor Webster.

2. The choice of subjects on the Manchester and Winterthur bell-kraters is very interesting.

3. *Cf.* The diadems on the reverse of the Manchester and Winterthur vases with that of the flute-player on the Vienna vase; with these *cf.* the diadems on Baltimore, Robinson Coll., *C.V.* III, pl. 25, 1–2.

4. Beazley, *Op. cit.*, 78

5. Beazley, *Op. cit.*, 76.

and most individual Campanian painter whom we might call the Manchester painter. This painter was under an exceptionally strong Cuman influence.[1]

For the version of the subject on the Manchester bell-krater, in which Hippolyte offers her girdle to Heracles, *cf. Arch. Zeit.* 1856, pl. 89; *Rep. d. Vases Peints I*, 384, 1–3.

For the date of the Manchester, Winterthur and Vienna vases see end of last section.

THE LIDDED LEKANIS M.M. IVE 26, Pl. VI, 2, THE TREFOIL OINOCHOE M.M. IVE 29, Pl. VII AND THE NECK-AMPHORA M.M. IVE 24, Pl. VIII.

The Lidded Lekanis M.M. IVE 26: Height 0·11½ cm. (lid included). Diameter 0·14½ cm. Provenance unknown. The colour of the clay is pink; the glaze is brown. The basis of the foot and the surface beneath it are reserved. The handles have double ridges. At the height of the handles a pattern of vertical red strokes (painted on the dark glaze).

On the edge of the lid a pattern of vertical red strokes (painted on the dark glaze). On the upper surface two female heads wearing " sakkos " (decorated with rows of dots), white diadem, ear-ring and necklace, and two large palmettes, each flanked by two small semi-palmettes touched with white colour. The moulded knob of the lid is decorated with reserved circular bands and a ray-pattern on its upper surface.

Cf. Würzburg 873, Langlotz pl. 250; back Jacobsthal *O.* pl. 59, a.

The Trefoil Oinochoe M.M. IVE 29: Height 0·30 cm. Diameter 0·16 cm. Provenance unknown. The colour of the clay is pink. The glaze is black. No miltos is applied on the reserved surfaces of the vase. The surface beneath the foot and the basis of the handle are reserved. On the neck a tongue-pattern; on the shoulder a reversed pattern of stylized waves to the left (with added yellow dots on the top of each).

1. *Cf.* The Vienna vase with the bell-krater Naples R.C. 144, *Jh.* 18, Beibl. 247, which Beazley attributed to the C.A. painter. The Manchester vase is characterized by a polychromy which long ago has been accepted as proper to the Cuman workshops (Patroni, 83; Gabrici, M.L. 22, 693).

The main scene consists of two women; the one on the left is sitting on a white-yellow rock on which she is leaning her left hand, while holding a cista (decorated with yellow colour) with white outline pastries and fruit (reserved and outlined with yellow) in her right. She wears an unsleeved girdled chiton (fastened with yellow brooches on the shoulders) and " sakkos " (tied with white-yellow ribbons), diadem, ear-ring, necklace, bracelets and shoes, all yellow. The standing woman on the right is similarly dressed but her " sakkos " has no ribbons and her girdle is thick with white-yellow beads. She holds a yellow mirror in the right hand and in her left a yellow thyrsos and a white-yellow cluster of grapes. In the background there are a window, two head-bands with ribbons and two rosettes, all touched with white-yellow.

The floral ornament under the handle consists of a big palmette flanked by two scrolls (which end in palmette like flowers) and two teeth-shaped ornaments.

Cf. Copenhagen 244, from S. Agata. *C.V.* pl. 246, 2.

The Neck-Amphora M.M. IVE 24: Height 0·55 cm. Diameter 0·20 cm. Provenance unknown. The colour of the clay is light pink; miltos is applied on the reserved surfaces of the body and neck. The glaze is black and bright. The mouth, handles and foot are moulded. The upper surface of the mouth, the inside surface of the handles, a thin horizontal band above (A) and (B), two horizontal bands round the foot, its basis and the surface beneath it are reserved. On both sides of the neck a pattern of stylized waves and a palmette underneath. On the shoulder a laurel-pattern to the left.

(A) Two women facing one another in a ritual scene. The one on the right is sitting on a white-yellow rock. She wears an unsleeved girdled chiton (fastened on the shoulders with two yellow brooches), and white-yellow " sakkos " (tied with white ribbons), diadem and shoes. She is decorated with yellow beaded ear-ring and necklace, and white-yellow bracelets. Her left hand rests on the rock, while her right holds a laurel (or olive) branch with yellow stem and white-yellow berries. The standing woman on the left is similarly dressed (part of her

" sakkos ", her diadem and necklace and one of her bracelets have almost disappeared). She holds a white-yellow cluster of grapes in her right hand and a patera (touched with white-yellow) with fruit (white-yellow) in her left. Between the two women there is a scroll (touched with white) ending in a palmette-like flower and flanked by two teeth-shaped ornaments. In the background there are a window, two rosettes and a head-band, all touched with white-yellow colour.

(B) Two draped youths (facing one another) wearing white-yellow diadems. In the background there are three rosettes, a window and a head-band, touched with white colour.

Beneath (A), (B) and floral ornament a stylized wave-pattern and a thin reserved band. The floral ornament under the handle consists of two scrolls flanked by palmettes and teeth-shaped ornaments.

Cf. Würzburg 876, Langlotz pl. 250.

With these three last pieces we come to the group of Campanian vases which has generally been assigned to Cumae.[1] Beazley accepted a main group, called the C.A. painter and three others, the Ready painter, the painter of New York 1000 and the A.P.Z. painter, who probably worked in the same workshop with him. To these a fourth has been lately added by Trendall, called the Nicholson painter.[2] The Manchester Museum has no vase which could be attributed to the first two, or the last painter. A few words on their style however would be useful, as the others are very much connected with them.

The C. A. painter[3] likes ritual scenes; women are often represented round a stele, or in the company of Oscan warriors[4] who are usually introduced in Campanian vase-painting in conventional compositions.[5] Scenes of a less precise character

1. *Cf.* Patroni, 79 onwards. Beazley accepts this origin as probable but not certain (*J.H.S.* 1943, 85).

2. Trendall, *Handbook to the Nicholson Museum*, Sec. ed. 331 and fig. 86.

3. Beazley, *Op. cit.*, 86—88.

4. See Trendall, *Op. cit.*, 331 ; Weege, *Oskische Grabmalerei*, *Jb.* 1909, 99—162.

5. See however, those on the Caivano ptr. hydria, Naples, from Caivano, *NSc.* 1931, 582 and 581, 1.

in which women appear holding branches, pateræ, phialæ, mirrors, drums, etc., are also frequent.[1] Mythological, dionysiac, and symposiac subjects are more scarce, though not entirely missing.[2] Characteristic are the female figures, often represented with added white colour on the naked surfaces and with drapery only round the lower parts of their bodies.[3] Their hair is usually dressed in the Apulian way. The treatment of the drapery is peculiar and difficult to define, but can be satisfactorily studied on the alabastron Dunecht. Cowdray, Tischbein 3, pl. 23 and Tillyard, pl. 40.[4]

The male figures represented on the obverses of the vases can be divided into the type of the Oscan warriors and the type of the youths with soft bodies, not unlike Heracles and Iolaos on the bell-krater M.M. IVE 30.[5] Figures often sit on fawnskins used as covers of rocks[6] and " klismoi ",[7] on cushions,[8] or some sort of " diphroi ocladiæ "[9], probably introduced under the influence of the Apulian " Prachtgefässe ".[10] The chair on which the woman on the reverse of the Wilno bell-krater is sitting is unusual.[11] The rocks on the C.A. painter vases are of Apulian type. Characteristic are the queer fish-bone shaped branches,[12] which occasionally come out of tree-trunks in the

1. *Cf.* Sèvres 52, from Basilicata. *C.V.* pl. 38, 14 and 18 ; Providence 97.099. *C.V.* pl. 29, 1.

2. *Cf.* Madrid 11024 (L. 371). Leroux pl. 47 ; Naples 2855, from S. Agata. A, *Jb.* 2, 125 ; A, Patroni 87 ; Dunecht, Cowdray, Tillyard pl. 40.

3. *Cf.* however the woman on the neck of Bremen, Biedermann. A, Schaal *Brem.* pl. 23.

4. *Cf.* also Sèvres 52, from Basilicata. *C.V.* pl. 38, 14 and 18 ; Wilno Univ. *C.V.* pl. 3 (Pol. 126), 20.

5. *Cf.* Naples RC 144, from Cumae. A, *ML.* 22, pl. 93, whence *Jh.* 18, beibl. 247 ; Würzburg 877. A, and side, Jacobsthal *O.* pl. 145 ; Langlotz pl. 249.

6. *Cf.* Bremen, Biedermann. A, and side, Schaal, *Brem.* pl. 23 and pl. 26, d.

7. *Cf.* Dunecht, Cowdray. Tischbein 3, pl. 23 ; Tillyard, pl. 40.

8. *Cf.* Dunecht, Cowdray. Tischbein 3, pl. 23 ; Tillyard, pl. 40.

9. *Cf.* Capua, from Carditello. *C.V.* IV, Er. pl. 33, 3 and pl. 34.

10. F.R. II, pl. 88, fig. 40.

11. *Cf.* Wilno, Univ. *C.V.* pl. 3 (Pol. 126), 20.

12. *Cf.* Naples RC 144, from Cumae. A, *ML.* 22, pl. 93, whence. *Jh.* 18, beibl. 247 ; Dunecht, Cowdray. Tischbein, pl. 23. Tillyard, pl. 40.

landscape.[1] In the background there are head-bands, windows, rosettes and phialæ; on some vases appears with slight differences what Tillyard (p. 150) describes as "an object of rectangular shape, containing two straight lines and a semi-circle; from it hangs a chain of dots and an inverted lotus-bell".[2] This object seems difficult to interpret and sometimes has the shape of a tablet with a figure sketched in it, corresponding to that on a Gnathian vase of the Manchester Whitworth Institute which has been connected with the use of the Roman "oscilla",[3] swung on trees under the influence of the Greek Aiora.[4] The floral ornament used by the C.A. painter can be studied on the following vases: Copenhagen inv. 9760. *C.V.* pl. 247, 1; Naples 2855, from S. Agata, A, Patroni 87; Bologna PU. 486. *C.V.* IV, Er pl. 6, 22—3.

The C.A. painter was strongly influenced by the Apulian vases produced in the last third of the fourth century. On the Persians Volute-krater in Naples the origin of many distinctive marks of our painter can be found.[5]

The style of the Ready painter has been defined as being "very like that of the C.A. painter but strangely exaggerated and stiffened".[6] The scenes are usually ritual; the Oscan warriors are missing and a citharode is often introduced.[7] The figures are never divided into two rows, or spread over different levels as often by the C.A. painter.[8]

1. *Cf.* Würzburg 877; Langlotz, pl. 249.

2. *Cf.* Capua, from Capua. *C.V.* IV, Er. pl. 46, 15 and 17; Providence 97099. *C.V.* pl. 29, 1; Wilno, Univ. *C.V.* pl. 3 (Pol.126), 20; Baltimore, Robinson, from Taranto. *C.V.* III, pl. 24, 2.

3. *Cf.* Webster, *Manchester Memoirs* lxxxiii, 203—204.

4. *Cf.* Immerwahr, *Choes and Chytroi. Trans. Amer. Philol. Association*, lxxvii, 1946.

5. *Cf.* The chair on the obverse of Würzburg 877 with those of the two councellors on the left of Dareios, on the Naples vase; also the incense stand on the Dunecht alabastron with that on the Persians krater; finally the stool on the reverse of Capua, from Carditello. *C.V.* IV, Er. pl. 33, 3 and 34 with that on which the last counsellor on the right of Dareios is sitting.

6. See Beazley, *Op. cit.* 88—89; *cf.* the attitudes of the figures on Michigan. *C.V.* pl. 31, 2; Copenhagen 259. *C.V.* pl. 246, 1.

7. *Cf.* Naples 808. A, Patroni, 163; Michigan. *C.V.* pl. 31, 2.

8. *Cf.* The C.A. painter vases: Bremen, Biederman. A, Schaal, *Brem.* pl. 23 and Copenhagen inv. 9760, *C.V.* pl. 247, 1.

The cistæ which women often hold are high and decorated with geometric patterns and the incense-stand appears with no cover at least twice ;[1] the fawnskin is used as cover of seats or as a seat itself.[2] Peculiar to this painter though found only once seems to be the pattern framing the scene on the oinochoe, Copenhagen 259.

The painter of New York 1000 is more important to us because two vases of the Manchester Museum can be attributed to him. As far as subject goes he is in the same line with the C.A. painter and under a strong Oscan influence,[3] but he seldom spreads his figures on different levels.[4] The women are not very different from those on the C.A.-painter vases ; they often wear a beaded girdle and their navel is sometimes visible through the dress.[5] In the background small branches of the type found on the obverse of the bell-krater London F191 are very frequent.

The clumsy wrapped youths on the reverse of Copenhagen inv. 9760, *C.V.* pl. 247, 1 and London F198, *C.V.* IV, Ea pl. 10, 9 are not found to my knowledge on vases by the painter of New York 1000 ; his are carefully drawn and wear as a rule a diadem with a row of beads above it,[6] which is also characteristic for the A.P.Z. painter.

For the types of floral ornament found on vases by the painter of New York 1000 cf. Michigan, *C.V.* pl. 31, 1 ; London F191, *C.V.* IV, Ea pl. 6, 5 ;[7] Würzburg 873, Langlotz pl. 250 ; Berlin 3022, from Capua, A and side, Jacobsthal *O.* pl. 58 ; Copenhagen 244, from S. Agata, *C.V.* pl. 246, 2. From that

1. *Cf.* Michigan, *C.V.* pl. 31, 2 and Naples 808, A, Patroni 163.

2. *Cf.* Naples 808, Patroni 163 ; Copenhagen 259, *C.V.* pl. 246, 1 ; Michigan, *C.V.* pl. 31, 2.

3. *Cf.* Toronto 391. Robinson and Harcum pl. 70 with the Oscan grave-paintings Weege, *Jb.* 1909, figs. 1, 3, 15 and pll. 9–10.

4. *Cf.* Würzburg 873, Langlotz 250 and Naples, from Caivano, *NSc.* 1931, 597 and 595, III.

5. *Cf.* Michigan, *C.V.* pl. 31, 1 ; Berlin 3022, from Capua, Jacobsthal *O.* pl. 58.

6. *Cf.* Michigan, *C.V.* pl. 31, 1 ; London F191, *C.V.* IV, Ea. pl. 6, 5 ; Toronto 391, Robinson and Harcum, pl. 70.

7. This should be distinguished from the last development of the floral ornament in Paestan Pottery in which " one single down-pointing fan palmette " is used with the scrolls (*cf.* Trendall, *Paes. Pottery,* 10).

point of view our painter is nearer the A.P.Z. painter than the C.A painter.

And now let me come to the Manchester vases. The lidded lekanis M.M. IVE 26 can be attributed to this painter on grounds of a comparison of the heads on its lid with those beneath the horizontal handles of the hydria Würzburg 873, Langlotz 250 (especially with that on the second reproduction). The head-dress with the exception of the ribbon and the white dots is similar; so is the treatment of the ear-ring, the diadem, the eyes and especially the nose and mouth, indicated with three dots.

The trefoil oinochoe M.M. IVE 29 can be attributed to the small group which in Beazley's classification forms the tail-end of the painter of New York 1000; its closest parallel is the oinochoe Copenhagen 244, from S. Agata, *C.V.* pl. 246, 2. The subject on both vases is almost similar and so is their shape and style (drapery, filling ornament, patterns on shoulders and neck).

The A.P.Z. painter likes ritual scenes but not warriors;[1] he does not seem to be interested in mythological subjects.[2] His female figures are treated very much like those on Apulian vases and so are the male ones who are of an effeminate type unless they represent warriors.[3] The Eros on the neck of the reverse of Villa Giulia inv. 22592 reminds one of the Hermaphrodite Erotes usual on Apulian vases. Objects like mirrors, drums, branches[4] and rocks are also apulizing.[5] The floral ornament has been already heralded on vases by the other painters of this group. Here it appears in its final development with the greatest use of teeth-shaped ornaments and most stylised.

1. *Cf.* however Naples, from Cumae, A, *ML.* 22, pl. 94.
2. *Cf.* however Villa Giulia inv. 22592, from Cumae, *C.V.* IV, Er. pl. 2, 1–3 and 5.
3. *Cf.* The vase of note 2.
4. *Cf.* Würzburg 876, Langlotz, pl. 250.
5. *Cf.* The mirrors on Würzburg 876; Villa Giulia inv. 22592, *C.V.* IV, Er. pl. 2, 1–3 and 5; London F195; Wilno, Society of Friends, *C.V.* pl. 1 (Pol. 124), 4; also the drums on Capua 7544 (P. 18), from Capua, *C.V.* IV, Er. pl. 26, 4–6.

The last Manchester vase in this series, the neck-amphora M.M. IVE 24 can be easily attributed to this painter ; its connection with Würzburg 876 is so strong that it would seem superfluous to discuss it.

Let me close this last chapter with a few words about the Nicholson painter.[1] One of his originalities seems to be the shape of the Toronto vase.[2] This is the only calyx-krater known to me in the whole apulizing group. The Nicholson painter is not far from the A.P.Z. painter and Trendall who introduced him as the fifth painter of this group related to him two vases which Beazley had already classified close to the A.P.Z. painter.[3] His hallmarks are a greater stylisation and the decoration of the seats on Toronto 409 and Sèvres 78, *C.V.* pl. 42. 5.

The Apulian influence on the C.A. painter and his followers would suggest a rather early date within the last quarter of the fourth century.

My thanks are due to Mr. David Baxandall, Curator of the Manchester City Art Gallery, for the permission to publish the vase pl. IV, 1–2 and to Mr. R. U. Sayce, Keeper of the Manchester Museum, for the permission to publish the vases pll. I—III and IV, 3—VIII.

The photographs reproduced on pll. I, II, III, V1, VI2, VII, VIII were taken by Mr. H. Spencer of the Manchester Museum, those reproduced on pl. IV, 1–2 were taken by Mr. G. A. Webb of the Manchester University Library, the photographs reproduced on pll. V, 2 and VI, 1 are mine.

I am deeply grateful to Professor T. B. L. Webster for reading my manuscript throughout and proposing various corrections.

1. *Cf.* Trendall, *Handbook to the Nicholson Museum, Second Edition* 331, fig. 86.

2. *Cf.* Toronto, 409, Robinson and Harcum, pl. 76.

3. *Cf.* Capua 7564 (P. 31), from Capua, *C.V.* IV, Er. pl. 17, 4–6 and Capua 7548 (P. 71), from Capua, *C.V.* IV, Er. pl. 47, 4–6.

A Discussion on the Equations of State.

By Dr. HERBERT RAMSDEN.*

A number of different forms of the gas equation have been suggested from time to time in the past, the most familiar being that of Van der Waals.[1] Other forms have been suggested by Dieterici, Reinganum, Clausius.[2]

None of these formulæ have been found to be completely satisfactory and this is not surprising because the actual forces between the molecules and the various other factors involved are not known with sufficient accuracy to allow the deduction of a gas equation which is founded on a sound theoretical basis. The various authors have made plausible assumptions in each case with regard to the intermolecular forces of attraction and repulsion and the size of the molecules, and in this way they derive equations which give a relationship between the three fundamental observable quantities p, v, and T. These quantities represent the pressure, volume, and temperature in degrees absolute.

No attempt is made in this paper to deduce another form for the gas equation based on new theories about the forces of molecular interaction. It will be shown that it is preferable to retain the gas equation in the form $(p+q)\ (v-b)=RT$ where q represents the effect of the forces of molecular interaction on the pressure exerted by the gas, and b represents the amount of space actually taken up in providing for the geometrical accommodation for the molecules. In this equation p and v represent respectively the pressure and volume as measured by the observer, and R is the universal gas constant and T is the temperature in degrees absolute.

The normal procedure in developing the Kinetic Theory of gases is to consider, in the first place, an Ideal Gas in which the molecules have no appreciable magnitude and in which there are no molecular forces, either of attraction or of repulsion. The pressure which such a gas exerts on the walls of the container is readily calculated to be given by the expression[3] $p=\frac{1}{3}\ \frac{nmc^2}{v}$ (1), where n is the number of molecules in the volume v, and m is the mass of each molecule, and c^2 is the mean square velocity

* Obituary on page i. Dr. Ramsden's paper was submitted to the Society by his executors.

of motion of the molecules and v is the volume of the containing vessel. If v is in ccs. then p is measured in dynes per sq. cm. (m measured in grams).

If the mean Kinetic Energy is considered to be proportional to the absolute temperature, then the expression (1) immediately leads to the well known expression which has been observed to represent experimental results to a very close approximation in the case of all gases when they are sufficiently far removed from the region of condensation, namely $pv = RT$. In this equation R is a constant for any given mass of gas and T is the temperature in degrees absolute.

This equation may be written in the form $pv = nkT$ where n represents the number of molecules in the volume v and k is the gas constant for a single molecule. This leads to the more general form $pv = RT$ where R is always given by multiplying the constant k by the number of molecules in the mass of gas under consideration. If $\frac{1}{2}\,mc^2$ is considered to be proportional to T we can write the proportionality in the form $\frac{1}{2}mc^2 = aT$ and then we have $a = \frac{3}{2}\,k$ giving the relationship between a and k.

If one now considers a gas in which there are intermolecular forces and also in which the molecules have a finite size, then it is logical to assume that even in all such cases

$$rf = RT$$

where r now represents the pressure which the molecules would have exerted if the forces of interaction had not been active and f represents the volume which is actually left over for the molecules to move around in after their finite sizes have been given due consideration. It is evident that r now represents a pressure which does not directly reveal itself to the observer because r is compounded of p and q, where p is the pressure which would be recorded on a manometer and q is the force of molecular attraction. The quantity r may be regarded as an intrinsic pressure capable of mathematical calculation from the Kinetic Theory and r will in future be referred to as the " total thermal pressure ".

Therefore the gas equation may now be written as $r\ (v-b) = RT$ or as $(p+q)\ (v-b) = RT$ because $r = p+q$.

So far this is quite orthodox and the equation now resembles that of Van der Waals apart from the fact that we have not gone so far as to assume that $q = \frac{a}{v^2}$ (where a is a constant for any particular gas under consideration).

In this paper it is maintained that the equation of state of a perfect gas, as well as that of a real gas, should also be written in the form $(p+q)(v-b) = RT$. It is obviously not incorrect to do this, but it is unusual to represent the equation of state of a gas in this way when q and b are zero.

However, for the sake of the general form of representation which will be developed in this paper, it is desirable that the equation of state of a perfect gas, as well as that of a real (actual) gas, should both be represented by the equation $(p+q)(v-b) = RT$.

FORM OF REPRESENTATION OF P AND V.

Instead of indicating experimental results by plotting p against v for different values of T it is suggested, in this paper, that these results could be better represented if r were to be plotted against $(v-b)$. This would lead to no useful result in itself because we should merely obtain a series of rectangular hyperbolæ corresponding to the various isothermals under consideration. If, however, the q curve is evaluated and inserted in the $v-b$ diagram as well as the r curve then the combined diagram is capable of conveying a considerable amount of useful information.

The theme of this paper is, therefore, to urge the adoption, in more frequent instances, of this form of r, $v-b$, representation in conjunction with a superposed q, $v-b$, curve in place of the more usual representation of experimental values of p plotted against the observed values of v.

DEDUCTION OF THE VALUES OF q AND b.

The actual quantities which are directly observed experimentally are p, v, and T and it is desirable to explain briefly the manner in which it is possible to deduce q and b from the experimentally observed quantities p, v, and T. Now we have

$(p+q)$ $(v-b)=RT$ and if it is assumed that neither q nor b are functions of temperature then we have

$$\left(\frac{\partial p}{\partial T}\right)_v = K_p = \frac{R}{(v-b)}$$

$$\left(\frac{\partial r}{\partial T}\right)_v = K_r = \frac{R}{(v-b)}$$

where K_p is the coefficient of the increase of the observed pressure with temperature at constant volume and K_r is the coefficient of the increase of the total thermal pressure with temperature at constant volume. Therefore $K_p = K_r$ if q and b are independent of T.

Carrying on from the above equations we can now write $p = K_pT - q$ and $r = K_rT$.

If we plot the values of pressure p against the absolute temperature T as obtained by experimental observation we shall obtain a line which is nearly straight but which may not pass through the origin if extrapolated backwards towards $T = 0$. The values would lie on a straight line of slope tan $\theta = K_p = \frac{R}{v}$ and the line would pass through the origin if the gas were a perfect gas obeying the law $pv = RT$. If the gas is not a perfect gas, but if q and b are independent of temperature, then the readings of p against T will still lie on a straight line but now the slope is $\frac{R}{v-b}$ and the line will not pass through the origin but the value of p at $T = 0$ is now $p = -q$.

Now the value of r plotted against T must be a straight line passing through the origin and of slope tan $\theta = K_r$.

There is a general inference, both on theoretical and on experimental grounds, to believe that the quantities q and b are independent of T (to a first approximation) and therefore the slope of the r line can be taken as having the same value as that of the p line. That is to say, that if q and b are independent of T, K_r will be equal to K_p and K_p is observed directly by experiment. Therefore $\frac{R}{v-b}$ can be determined by experiment and

seeing that R is known, and v is directly observable, it follows that b can be evaluated immediately. When the value of b is known for any observed value of p, v and T, then r can be readily calculated from the expression

$$r = \frac{RT}{(v-b)}.$$

Now r is known and therefore q is readily determined because $q = r - p$.

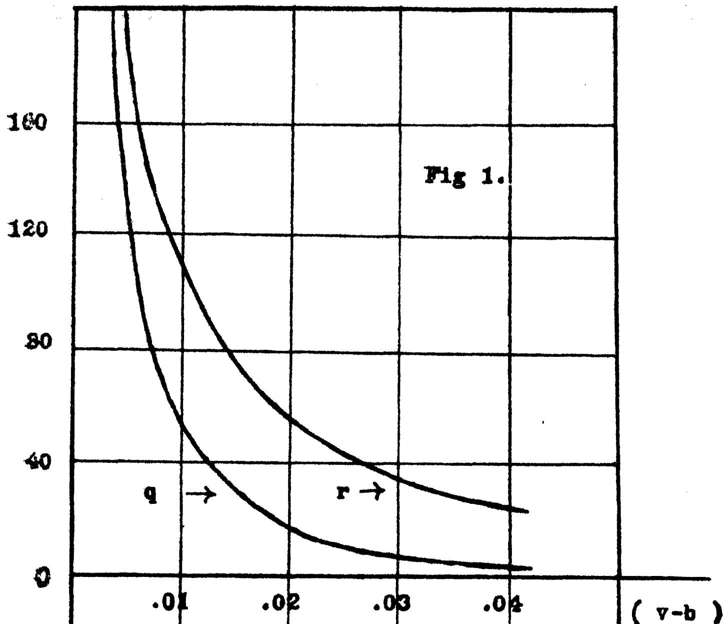
If the experimentally observed values of p against T (at constant volume) give rise to a line which is slightly curved, this may be due to a variation of q with temperature but it could also be due to a variation of b with temperature.

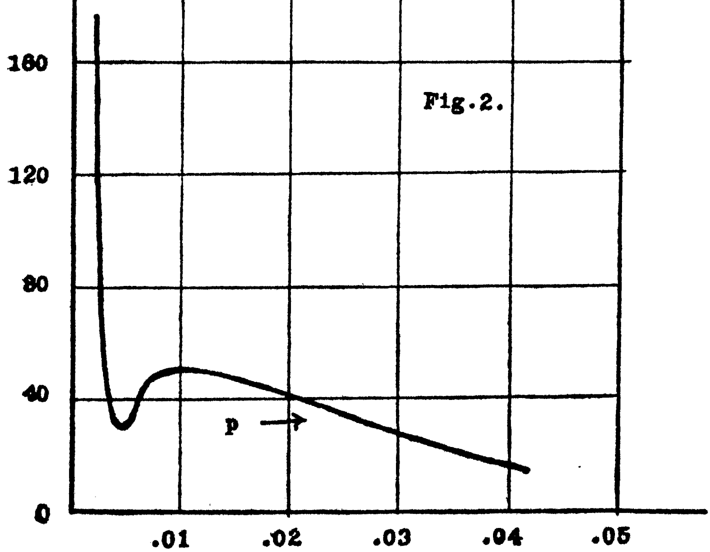
In cases where the p, T, lines show such curvature it is necessary to take the slope of the tangent to this curve at any required value of T. This will give a value to the coefficient K_p which is typical of the particular temperature at which the gas is being considered. Let this value of K_p be denoted by $(K_p)_T$. Then we now have $\frac{R}{v-b} = (K_p)_T$, and the determination of the values of q and b is carried out as already described in the case where $\left(\frac{\partial p}{\partial T}\right)_v$ had a constant value for all observed values of T.

The above account of the method of determination of q and b is merely one way of dealing with the matter. The general determination of q and b as they appear in their equivalent form in the Van der Waals' equation is well covered in all text books on this subject. It is usual to indicate how q can be determined by the pressure coefficient method as indicated above[4] and also by observations on the tensile strength and latent heat of evaporation.[5]

THE $r(v-b)$ REPRESENTATION.

Having now indicated how the values of q and b can be determined, it is possible to express any observed values of p, v and T in terms of a graph of r against $(v-b)$ along with the associated curve of q against $(v-b)$. The combination of the r and q curves plotted against $v-b$ (for various values of T)


160
120
80
40
0
Fig 1.
q →
r →
.01
.02
.03
.04
(v-b)


160
120
80
40
0
Fig.2.
p →
.01
.02
.03
.04
.05

convey all the information which would be contained in a direct plot of p against v for various values of T. Also it is claimed in this paper that this mode of graphical representation is considerably more informative, in a visual sense, to a student because it :—

(1) Emphasises the presence of the thermal pressure.

(2) Illustrates the mathematical invariance of the thermal pressure in so far as this pressure is always indicated by a curve of hyperbolic form on the r, $v-b$, diagram.

(3) Indicates the rapid increase of q for small values of v.

(4) Illustrates that the manifested pressure p is the residual pressure available after a portion of the thermal pressure has been neutralised by the intermolecular attraction.

It is not claimed that this mode of representation is a better way in which to express the experimental results. The best way in which experimental results can be expressed is by a clear representation of the way in which they have been recorded. However, the r, $v-b$, representation is, in many instances, a better way in which to express the analysis of the experimental results and for this reason it can now be seen why it was desired to retain the gas equation in the form $(p+q)\ (v-b)=RT$ even when dealing with a perfect gas. The idea is that the hyperbolic invariance of the r, $v-b$, curves should be predominant in the representation.

It is not possible to give here many illustrations of this r, $v-b$, form of representation without making the paper unduly long, but it is desirable to give one illustration in order to indicate the nature of the r, $v-b$, and q, $v-b$, curves and their relationship to the directly observed quantities p, v, and T.

In Figure (2) a typical p, v, isothermal (as calculated from the Van der Waals formula) is reproduced in the conventional manner, and in Figure (1) the associated curves are given on the r, $v-b$, mode of representation. The curves relate to results obtained for Carbon Dioxide and relate to a temperature of 20° C. In order to enable the values of $(r-q)$ from the r, $v-b$, diagram to be compared directly with the corresponding values of p on the p, v, diagram, the p, v, diagram has been drawn in

Figure (2) so that the abscissa is $v-b$ and not v alone. The values of the ordinates of p on Figure (2) are given by the corresponding values of the intercept $r-q$ from Figure (1) for any particular value of $v-b$. Figure (2) has been drawn directly underneath Figure (1) so that this relationship will be quite clear.

REFERENCES.

(1) Dynamical Theory of Gases. J. H. Jeans. Cambridge University Press. Page 128.

(2) Kinetic Theory of Gases. E. Bloch. Methuen & Co. Chapter 2.

(3) Reference 1. Page 116.

(4) Reference 1. Page 138.

(5) General Physics. E. Edser. Macmillan & Co. Page 357.

PROCEEDINGS OF THE MANCHESTER LITERARY AND PHILOSOPHICAL SOCIETY.

Obituary

Herbert Ramsden

Born, 1865 *Died*, *December 23rd*, 1947

Dr. Herbert Ramsden, M.D., J.P., who was elected a member of the Society in 1901, was one of a family of prominent physicians in the Saddleworth district of Yorkshire. His father, Dr. W. H. F. Ramsden, practised there for many years. Of five brothers three were doctors and Dr. Ramsden's surviving sister is the widow of a doctor. He was held in high esteem by members of the medical profession in Manchester and the surrounding towns. Had he chosen he might have been a brilliant consulting specialist. He was a frequent contributor to *Lancet* and kept himself in the forefront of medical thought.

From 1900 to 1935 he was Medical Officer of Health for Saddleworth. It was when the present Urban District of Saddleworth was formed that Dr. Herbert took over. His reports were always original and advanced in outlook. Continually he stressed the need for hygienic conditions in the production of milk and appealed to the Council for a refuse destructor in Saddleworth.

A bachelor, Dr. Ramsden was formerly a keen worker for the Saddleworth Section of the St. John Ambulance Association, for which he received the higher honour in London a few years before the war. He was one of the oldest members of the Saddleworth Bench of Magistrates, his appointment dating to 1919, and gave valuable service.

Small in stature, slender in build, Dr. Ramsden possessed a well proportioned figure. In the briefest encounter, the essential

dignity of the man might never by any chance be overlooked. He was always neatly and immaculately dressed. His love of work, his unfailing application to duty, were combined with a gentle gaiety of disposition and a quiet but impelling charm of manner which immediately captivated and made friends of those with whom he came in contact.

Of his home at Briarfield, Dobcross, freedom was ever the keynote. There the happy guest awaited no formal invitation nor did he ever look for any spoken welcome. He found his welcome in the air he breathed, in a house where other happy guests were never absent. As one may readily imagine, in a numerous and intensely active household—in a doctors' busy house as this one—many people and many things went to the making of the varied attractions of Briarfield, contributing to the delightful informality which invariably reigned there. Yet over all, as one could never be unaware, there presided, even were he absent at times, with suave, unseen and effortless authority, as it always seems, Herbert Ramsden himself, as the undoubted *genius loci* when one thinks of Briarfield as it was in those less austere days before the second World War.

It has been said that Dr. Ramsden believed in the freedom of the individual. He was a stranger to all esoteric or partisan cults, nor did political theories interest him. His approach to human problems was direct and personal. He helped others by his medical skill and, scarcely less, by his universal kindliness, his unaffected interest in their own particular affairs and difficulties and his genuine concern for their welfare. Few men can have had more friends and fewer enemies than Dr. Ramsden. Humanity he accepted as he found it, sharing in full measure, with zest and contentment, both its burdens and its pleasures. His patients adored him, and almost up to the day of his death he still continued to attend many of his old private patients who would have no other doctor.

He was meticulously thorough and painstaking in everything he undertook, even in tasks outside his usual genre such as painting, but his favourite hobby was field botany in which he was very learned. He was also notably interested in the study of molecular physics.

There were many facets to Dr. Ramsden's character, but they were all aspects of a single most harmonious personality, motivated equally by the highest sense of duty and an innate and wholly genuine affection and love for his fellow men.

He is commemorated by the Herbert Ramsden Fund which he left to the Society for the endowment of an annual lecture on " Recent Discoveries in Science ".

H. B.

Chesham, August 29th, 1949.

PROCEEDINGS

Session 1948–49

Eight ORDINARY MEETINGS were held during the session, at which lectures were delivered as follows :

1948.

Oct. 7th. Conversazione— Whitworth Art Gallery. " Dürer's Melancholia ", by Sir Thomas Barlow.

Oct. 18th. " Some account of a Research Adventure within the Industrial Pattern ", by Dr. C. J. T. Cronshaw.

Nov. 15th. " Conceptions of Force in Physics ", by Professor L. Rosenfeld. (Wilde Memorial Lecture.)

Dec. 13th. " The History and Vegetation of some Cheshire Meres ", by Miss E. M. Lind, B.Sc., Ph.D.

1949.

Jan. 24th. A Symposium on " Juvenile Delinquency ", by C. T. Cape, Esq., J. C. Macintyre-Millar, Esq., Dr. Mary Burbury and Mrs. E. G. F. Birley, J.P.

Feb. 21st. " Mechanised Trial and Error : Some Examples of Electrical Automatic Control ", by Professor F. C. Williams, O.B.E. (Percival Lecture.)

Mar. 14th. " The Modern Trends in Education ", by Rt. Hon. R. A. Butler, M.A., F.R.G.S., M.P. (Clayton Memorial Lecture.)

Apr. 11th. "The Manorial Mills of Manchester, 1515—1839", by R. F. I. Bunn, M.A.

The Annual General Meeting was held on April 27th, 1949, in the Portico Library.

SOCIAL PHILOSOPHY SECTION.

ANNUAL GENERAL MEETING, WEDNESDAY, NOVEMBER 3RD, 1948.

The following were elected Officers and Members of Committee for the year 1948–49:

Chairman:	Professor B. A. Wortley.
Vice-Chairman:	Professor D. M. Emmet.
Secretary:	Mr. R. N. Spann.

AFTERWARDS AN ORDINARY MEETING WAS HELD WHEN M. Bertrand de Jouvenel gave a lecture on

"The Strategy of Freedom".

ORDINARY MEETING, NOVEMBER 10TH, 1948.

Dr. W. D. Falk gave a lecture on

"Morality and Nature".

ORDINARY MEETING, NOVEMBER 27TH, 1948.

J. M. D. Pringle introduced a discussion on

"Propaganda in Relation to the Press".

ORDINARY MEETING, DECEMBER 15TH, 1948.

J. Coatman, C.I.E., M.A., introduced a discussion on

" Propaganda in Relation to Broadcasting ".

ORDINARY MEETING, JANUARY 19TH, 1949.

Henry Durant gave a lecture on

" Measuring Public Opinion ".

ORDINARY MEETING, FEBRUARY 16TH, 1949.

Professor L. C. Knights gave a lecture on

" The Literary Mind and the Study of Society ".

ORDINARY MEETING, MARCH 16TH, 1949.

Michael Oakeshott introduced a discussion on

" What is Political Philosophy ? "

ANNUAL GENERAL MEETING, SATURDAY, MAY 7TH, 1949.

The following were elected Officers and Members of Committee for the year 1949–50 :

Chairman :	Professor B. A. Wortley.
Vice-Chairman :	Professor D. M. Emmet.
Secretary :	Mr. R. N. Spann.
Committee :	Mr. R. F. I. Bunn.
	Mr. John Coatman.
	Professor E. Devons.
	Mr. Neil Pearson.
	Dr. E. J. F. James.

AFTERWARDS AN ORDINARY MEETING WAS HELD WHEN

Professor B. A. Wortley gave a lecture on

" Legal and Illegal Wars ".

CHEMICAL SECTION.

ORDINARY MEETING, OCTOBER 27TH, 1948.

Dr. E. J. F. James, M.A., D.Phil., gave a lecture on

" Chemistry and Education ".

ORDINARY MEETING, NOVEMBER 24TH, 1948.

Dr. Metcalfe Brown, M.D., D.P.H., gave a lecture on

" Chemistry and Public Health ".

ORDINARY MEETING, JANUARY 26TH, 1949.

Mr. H. Stevenson, F.R.I.C., introduced a discussion on "Long Term Policy in the Chemical Industry, especially in Textiles".

ORDINARY MEETING, FEBRUARY 23RD, 1949.

Dr. Naunton gave a lecture on

" Rubber and Chemistry ".

ORDINARY MEETING, MARCH 30TH, 1949.
(Held at the Shirley Institute).

Dr. Hill (B.C.I.R.A.) gave a lecture on

" Chemistry at the Shirley Institute ".

ANNUAL GENERAL MEETING, WEDNESDAY, APRIL 27TH, 1949.

The following were elected Officers and Members of Committee for the year 1949–50:

Chairman:	E. N. Marchant, A.R.I.C.
Secretary:	H. Stevenson, F.R.I.C.
Committee:	Miss Lever.
	Mr. Gudgeon.
	Dr. Rose.
	Mr. Straatman.

AFTERWARDS AN ORDINARY MEETING WAS HELD WHEN

Mr. W. A. Silvester, M.Sc., introduced a discussion on

"Scientific Man Power—Chemical".

ANNUAL REPORT OF COUNCIL, APRIL, 1949.

Membership.

During the session 1948–49, twenty-one new members were elected, five of whom are student associate members, bringing the total up to 215 including sixteen life members. There were two deaths and twenty-one resignations during the year.

The Council regrets to record the deaths of Dr. W. H. Bentley, on June 19th, 1948, and Mr. A. McLean Ranft, on October 8th, 1948, both Ordinary Members of the Society. Mr. Ranft was a former member of Council from 1933 to 1941 and Hon. Auditor of the Society for the years 1946 and 1947.

At a Council Meeting on October 18th, 1948, the honour of Corresponding Membership of the Society was awarded to the following past officers : Mr. John Allan, Hon. Secretary from 1923 to 1928, and Mr. D. C. Henry, Hon. Secretary from 1927 to 1936. On December 13th, 1948, Professor W. H. Lang, who was Hon. Secretary from 1924 to 1926 was also awarded Corresponding Membership in recognition of his services.

Meetings.

The Annual General Meeting was held at the Portico Library on April 28th, 1948, when Dr. E. J. F. James was elected President of the Society.

The winter session commenced with a Social Evening at the Whitworth Gallery on October 7th. Sir Thomas Barlow gave an address on " Dürer's Melancholia and its Astrological Background ".

The Wilde Memorial Lecture was held on November 15th in the Reynolds Hall of the Manchester College of Technology, when Professor L. Rosenfeld, Ph.D., spoke on " Conceptions of Force in Physics ".

The Dr. Thomas Percival Lecture was delivered by Professor F. C. Williams, O.B.E., D.Sc., D.Phil., A.M.I.E.E., at the Manchester University on February 21st. It was preceded by a tea, given by invitation of the University Council to members of the society, who afterwards heard Professor Williams speak on " Mechanised Trial and Error : some examples of Electrical Automatic Control ".

The Clayton Memorial Lecture was given by Rt. Hon. R. A. Butler, M.A., F.R.G.S., M.P., on March 14th, 1949, in the Reynolds Hall of the Manchester College of Technology who spoke on " The Modern Trends in Education ".

Details of other meetings will be found in the record of Proceedings.

Council Meetings.

Eight Council Meetings were held during the session.

On behalf of the Society the Council tenders its thanks to the authorities of the University of Manchester and the Manchester College of Technology for their kindness in allowing the use of their rooms for lectures and Council Meetings.

Chemical Section.

There have been six meetings of the Section, details of which will be found in the record of Proceedings. Mr. E. N. Marchant, A.R.I.C., was re-elected Chairman of the Section and Mr. H. Stevenson, F.R.I.C., Hon. Secretary for the session 1948–49.

Social Philosophy Section.

There have been six meetings of the Section, details of which will be found in the records of Proceedings. Professor B. A. Wortley was appointed Chairman of the Section and Mr. R. N. Spann, M.A., Hon. Secretary for the session 1948–49.

The Library.

The remains of the Society's Library, together with books and journals received since the destruction of the Society's premises at George Street are deposited in a special collection at the Central Library, Manchester. Members of the Society may consult books and journals in this special collection—other than current journals which are retained for a period in the Portico Library.

Portico Library.

Council wishes on behalf of the Society to express its appreciation of the co-operation of the authorities of the Portico Library which is the registered address of the Society.

John Dalton Medal.

Professor P. M. S. Blackett's work in the field of science was officially recognised by Council at a meeting on December 13th, 1948. He was awarded the Dalton medal which will be presented at a Social in October, 1949, when he will also give a lecture to the Society.

Dalton Relics.

Council has agreed for certain relics to be sent to the South Kensington Museum on loan.

Trustees.

The Society's property has been transferred from trustees to the Society.

Gifts.

The Council expresses the Society's thanks to the donors of the following gifts :—

Four early volumes by John Dalton and twelve Board of Agriculture Volumes dated 1804, 1805, 1807 and 1818, from the Royal Agricultural Society.

Portrait of Dr. Dalton, four engravings of Dr. Dalton, portrait of Rev. George Walker, President of Society 1805—1806 ; List of members of the Society, March, 1827, certificate of membership for Mr. George William Wood, April 24th, 1807 ; from Miss D. Wood, of Dorking, Surrey.

£1,000 from the trustees of Dr. Herbert Ramsden—a former member of the Society—to endow an annual lecture on recent discoveries in science. Council have decided to name this lecture the "Ramsden Lecture".

Five back numbers of Memoirs and a book by John Dalton written in 1840 on the Phosphates and arseniates, from Miss Chadwick.

"Dalton's Atomic Theory", by Henry E. Roscoe and Arthur Harden (1896) from Mr. H. Stevenson.

The portrait of Joule presented by Dr. J. R. Ashworth has been hung in the entrance hall of the Manchester Central Library.

Accounts.

An audited financial statement is attached, together with particulars of assets and liabilities.

NOTE.—The Treasurer's Accounts of the Session 1948–49 *have been endorsed as follows:*

April, 1949, Audited and found correct.

We have seen the Banker's certificate that they hold £375 3½ % War Loan Stock : £75 Certificate No. 77/19724/7 ; £300 Certificate No. 82/49566. £400 3 % War Stock 1955–49 ; Certificate No. 41/397579. £400 3 % War Stock 1955–59 ; Certificate No. 41/397580. £250 3 % Defence Bonds : Bond Book No. X. 751740. £1,225 Great Western Railway Co. 5 % Consolidated Preference Stock :

£100 Certificate No. 31794 £1,000 Certificate No. 31792 £125 Certificate No. 31796	*NOW* £1,533 10s. 11d. British Transport 3 % Guaranteed Stock 1978–88.

£7,500 Gas, Light & Coke Company Ordinary Stock : £5,500 Certificate No. 340891 ; £2,000 Certificate No. 347456. £100 East India Railway Company 4½ % Annuity Class A Stock : Certificate No. 25656. £700 4 % Funding Stock 1960–90 : £500 Certificate No. 34185 ; £200 Certificate No. 23/3457. £1,000 British Electricity 3 % Guaranteed Stock, 1974–77. One sealed parcel marked A. One sealed parcel marked B. One sealed parcel marked C. One locked cash box marked "Dalton Medals, etc." One sealed envelope marked "Board of Trade Deferment Notice".

We have verified the balances of the various accounts with the banker's pass books.

(*Signed*) W. A. SILVESTER.

P. F. R. VENABLES.

April, 1949.

MANCHESTER LITERARY

H. Hayhurst, Treasurer, in Account with the

GENERAL

	£	s.	d.	£	s.	d.
To cash in Treasurer's Hands, April 1st, 1948 ...				24	11	10
,, Members' Subscriptions :—						
Full Rate Arrears	14	14	0			
,, ,, 1948–49...	189	0	0			
,, ,, In advance	7	7	0			
Half Rate 1948–49	3	13	6			
Student Associate Subscriptions	1	5	0			
				215	19	6
,, Life Compositions				18	18	0
,, Dividends :—						
£75 3½ % War Loan	2	12	6			
£1,000 3 % British Electricity	3	8	9			
				6	1	3
,, Transfers :—						
Wilde Endowment Fund	299	7	0			
Natural History Fund	25	6	0			
Sir J. Larmor Fund	7	10	0			
Joule Memorial Fund	14	11	7			
				346	14	7
,, Sale of Publications				39	18	9
,, Refund of Income Tax 1947–48				28	0	1
,, Dr. J. R. Ashworth for Joule Portrait ...				105	0	0
,, Wilde Fund Frame for Portrait				32	10	0
,, H. Ramsden Bequest				1,000	0	0
,, Loan from Wilde Fund				157	17	8
,, Balance due to Bankers March 31st, 1949 ...				387	11	9
				£2,363	3	5

AND PHILOSOPHICAL SOCIETY.

Society, from April 1st, 1948, to March 31st, 1949.

FUND.

	£	s.	d.	£	s.	d.
By Balance due to Bankers, April 1st, 1948 ...				465	10	3
,, Chief Rent (Net) and Income Tax Schedule D				12	18	1
,, Administrative Charges :—						
State Insurance	7	9	3			
Office Expenses	6	0	0			
Telephone	0	16	1			
Printing and Stationery	375	11	10			
Lecturer's Fees and Expenses	15	14	0			
Postage and Carriage	30	17	8			
Hire of Rooms	6	13	6			
General Insurance	5	16	5			
Miscellaneous Expenses	9	1	4			
				458	0	1
,, Donation to Whitworth Art Gallery				10	10	0
,, Catering at Reception				17	6	6
,, Contribution toward expenses of Portico Library				160	10	0
,, Legal Expenses				83	17	6
,, Purchase of £1,000 British Electricity 3 % Stock				995	0	0
,, Joule Portrait and Frame				137	10	0
,, Subscriptions to Societies :—						
North-Western Naturalists' Union ...	0	14	0			
Palæontographical Society	1	1	0			
Lancashire and Cheshire Fauna Committee	1	1	0			
Prehistoric Society	1	16	0			
Ray Society	1	1	0			
,, "Nature"	4	10	0			
				10	3	0
,, Bank Charges				7	13	9
,, Cash in Treasurer's Hands				4	4	3
				£2,363	3	5

WILDE ENDOWMENT FUND, 1948–49.

	£	s.	d.		£	s.	d.
To Cash at Bank, April 1st, 1948	457	18	9	By Salary of Assistant Secretary	150	0	0
,, Dividend on £7,500 Gas Light and Coke Company's Ordinary Stock	206	5	0	,, Cheque Book	0	8	4
,, Interest on £400 3 % War Stock 1955–59	6	12	0	,, Cash transferred to General Fund for cost of frame of Joule Portrait	32	10	0
,, Refund of Income Tax	174	3	0	,, Transfer to General Fund	299	7	0
				,, Cash in Treasurer's Hands	24	0	0
				,, Loan to General Fund	157	17	8
				,, Cash at Bank, March 31st, 1949	180	15	9
	£844	18	9		£844	18	9

BUILDING FUND, 1948–49.

	£	s.	d.		£	s.	d.
To Balance at Bank, April 1st, 1948	292	6	11	By Balance at Bank, April 1st, 1949	338	6	7
,, Interest on £700 Funding Loan 4 % Stock	28	0	0				
,, Interest on £400 3 % War Stock, 1955–59	12	0	0				
,, Bank Interest	5	19	8				
	£338	6	7		£338	6	7

JOULE MEMORIAL FUND, 1948–49. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Dividend on £100 East India Railway Company's 4½ % Annuity Class A Stock	4	1	7	By Cash transferred to General Fund	14	11	7
,, Interest on £300 3½ % War Stock	10	10	0				
	£14	11	7		£14	11	7

NATURAL HISTORY FUND, 1948–49. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Interest on £1,533 10s. 11d. British Transport 3 % Guaranteed Stock, 1978–88	25	6	0	By Cash transferred to General Fund	25	6	0
	£25	6	0		£25	6	0

SIR JOSEPH LARMOR FUND, 1948–49. (Included in the General Account.)

	£	s.	d.		£	s.	d.
To Interest on £250 Defence Bonds	7	10	0	By Cash Transferred to General Fund	7	10	0
	£7	10	0		£7	10	0

Statement relating to the Society's Property as on March 31st, 1949.

Liabilities.	£	s.	d.
Amount due to Bank on General Account...	387	11	9
Liability for Volume 89 (In the press) estimated	150	0	0

Assets.	£	s.	d.	£	s.	d.
Arrears of Subscriptions, 1948–49				5	5	0
Cash Balance :—						
In Bank, Building Fund...	338	6	7			
,, ,, Wilde Fund	180	15	9			
,, Treasurer's hands...	28	4	3			
				547	6	7
				£552	11	7

Investments :—

£7,500 Gas Light and Coke Company's Ordinary Stock (W.E.F.) ... ...
£400 3 % War Stock, 1955—1959 (W.E.F.) ... ...
£700 4 % Funding Loan (B.F.) ... ...
£400 3 % War Stock, 1955—1959 (B.F.) ... ...
£100 East India Railway Company's 4½ % Annuity Class A (J.M.F.) ... ...
£300 3½ % War Stock (J.M.F.)... ... ...
£1,533 10s. 11d. British Transport 3 % Guaranteed Stock 1978–88 (Nat. Hist. F.) ....
£75 3½ % War Loan Stock, 1929–47 (G.F.) ... ...
£250 Defence Bonds (Sir J. Larmor F.) ... ...
£1,000 British Electricity 3 % Stock ... ...
Market Value at March 31st, 1949, £13,761.

Income Tax : A claim for repayment of income tax in respect of the year 1948–49 is in course of preparation and will be forwarded to the Inland Revenue.

Loss as a result of enemy action : The claim in connection with the contents of the House and Library which was situate at George Street, Manchester, has been settled at £20,833. This amount has not been paid to the Society and no information is available with regard to the date on which payment will be made. Interest is accruing on the sum outstanding.

The claim in respect of the Society's property which was situate at 36 George Street, also 21 Back George Street, Manchester, has not been settled.

THE WILDE LECTURES.

1897. (July 2.) "On the Nature of the Röntgen Rays." By Sir G. G. STOKES, Bart., F.R.S.

1898. (Mar. 29.) "On the Physical Basis of Psychical Events." By Sir MICHAEL FOSTER, K.C.B., F.R.S.

1899. (Mar. 28.) "The newly-discovered Elements; and their relation to the Kinetic Theory of Gases." By Professor WILLIAM RAMSAY, F.R.S.

1900. (Feb. 13.) "The Mechanical Principles of Flight." By the Rt. Hon. LORD RAYLEIGH, F.R.S.

1901. (April 22.) "Sur la Flore du Corps Humain." By Dr. ELIE METCHNIKOFF, For. Mem.R.S.

1902. (Feb. 25.) "On the Evolution of the Mental Faculties in relation to some Fundamental Principles of Motion." By Dr. HENRY WILDE, F.R.S.

1903. (May 19.) "The Atomic Theory." By Professor F. W. CLARKE, D.Sc.

1904. (Feb. 23.) "The Evolution of Matter as revealed by the Radio-active Elements." By FREDERICK SODDY, M.A.

1905. (Feb. 28.) "The Early History of Seed-bearing Plants, as recorded in the Carboniferous Flora." Dr. D. H. SCOTT, F.R.S.

1906. (March 20.) "Total Solar Eclipses." By Professor H. H. TURNER, D.Sc., F.R.S.

1907. (Feb. 18.) "The Structure of Metals." By Dr. J. A. EWING, F.R.S., M.Inst.C.E.

1908. (March 3.) "On the Physical Aspect of the Atomic Theory." By Professor J. LARMOR, Sec.R.S.

1909. (Mar. 9.) "On the Influence of Moisture on Chemical Change in Gases." By Dr. H. BRERETON BAKER, F.R.S.

1910. (Mar. 22.) "Recent Contributions to Theories regarding the Internal Structure of the Earth." By Sir THOMAS H. HOLLAND, K.C.I.E., D.Sc., F.R.S.

SPECIAL LECTURES.

1913. (Mar. 4.) "The Plant and the Soil." By A. D. HALL, M.A., F.R.S.
1914. (Mar. 18.) "Crystalline Structure as revealed by X-rays." By Professor W. H. BRAGG, M.A., F.R.S.
1915. (May 4.) "The Place of Science in History." By Professor JULIUS MACLEOD, D.Sc.

DALTON MEMORIAL LECTURES.

1931. (Mar. 17.) "Atoms and Electrons." By Sir JOSEPH J. THOMSON, O.M., D.Sc., F.R.S.
1944. (Oct. 10.) "The Atomic Theory." By Professor A. D. RITCHIE.

JOULE MEMORIAL LECTURES.

1920. (Dec. 14.) "The Work and Discoveries of Joule." By Sir DUGALD CLERK, K.B.E., D.Sc., F.R.S.
1922. (Dec. 5.) "The Rise in Motive Power and the Work of Joule." By Sir CHARLES A. PARSONS, O.M., K.C.B., M.A., D.Sc., F.R.S.
1924. (Mar. 4.) "Thermodynamics in Physiology." By A. V. HILL, O.B.E., M.A., Sc.D., F.R.S.
1928. (Mar. 20.) "Sub-Atomic Energy." By Professor A. S. EDDINGTON, M.A., D.Sc., LL.D., F.R.S.
1930. (Feb. 18.) "Science and Problems of the Times." By A. P. M. FLEMING, C.B.E., M.Sc., M.I.E.E.
1933. (Mar. 14.) "The Psychology of Musical Appreciation." By CHARLES S. MYERS, C.B.E., F.R.S.
1934. (Feb. 27.) "The Expanding Universe as a Thermodynamic System." By Professor E. A. MILNE, M.A., D.Sc., F.R.S.
1936. (Feb. 11.) "The Upper Atmosphere." By Professor E. V. APPLETON, M.A., D.Sc., LL.D., F.R.S.
1938. (Mar. 8.) "The Attainment of Low Temperatures." By Dr. C. G. DARWIN, M.C., M.A., F.R.S.
1940. (Mar. 19.) "New Applications of Physics to Medicine." By Professor JAS. CHADWICK, F.R.S.

1942. (Nov. 10.) "Man and the Weather." By Professor DAVID BRUNT, F.R.S., M.A., Sc.D.

1946. (Feb. 5.) "Atomic Energy." By Professor P. M. S. BLACKETT, F.R.S.

1948. (Jan. 26.) "Determinism in the Physical World." By Sir GEORGE P. THOMSON, F.R.S.

WILDE MEMORIAL LECTURES.

1926. (Mar. 9.) "Brains of Apes and Men." By G. ELLIOT SMITH, M.A., M.D., F.R.S.

1927. (Mar. 22.) "Physiology of Life in the High Andes." By J. BARCROFT, C.B.E., F.R.S.

1929. (Mar. 19.) "The Nature and Origin of Human Speech." By Sir RICHARD PAGET, Bart.

1932. (Mar. 15.) "Man's Place in Nature as shown by Fossils." By Sir ARTHUR SMITH-WOODWARD, LL.D., F.R.S.

1935. (Feb. 12.) "Some Sex Problems in the Fungi." By Professor Dame HELEN GWYNNE VAUGHAN, G.B.E., LL.D., D.Sc., F.L.S.

1937. (Feb. 16.) "Some Problems of the New Stone Age." By HAROLD J. E. PEAKE, M.A., F.S.A.

1939. (Mar. 14.) "Palæolithic Man in the North Midlands." By LESLIE ARMSTRONG, M.C., F.S.I., F.S.A.

1941. (Apr. 29.) "A New Era in Medicinal Treatment." By Sir HENRY H. DALE, President of the Royal Society.

1945. (Mar. 13.) "Some Antibiotics with Special Reference to Penicillin." By Sir HOWARD FLOREY, F.R.S.

1946. (Nov. 18.) "The Tides." By Professor J. PROUDMAN, F.R.S.

1948. (Nov. 15.) "Conceptions of Force in Physics." By Professor L. ROSENFELD.

CLAYTON MEMORIAL LECTURES.

1947. (Feb. 17.) "Transitions in Thought and Thought in Transition." By Professor H. J. FLEURE, F.R.S.

1947. (Nov. 24.) "Smoke Abatement." By Dr. METCALFE BROWN, M.D., D.P.H.

1949. (Mar. 14.) "The Modern Trends in Education." By Rt. Hon. R. A. BUTLER, M.A., F.R.G.S., M.P.

1949. (Nov. 14.) "Hybrid Vigour in Plants." By Professor E. ASHBY, D.Sc., D.I.C.

PERCIVAL MEMORIAL LECTURES.

1947. (Feb. 11.) "Process and Record : Aspects of Botanical Science." By Professor C. W. WARDLAW, D.Sc., F.R.S.E.

1948. (Feb. 16.) "National Industrial Life and the Doctor." By Professor R. E. LANE, F.R.C.P.

1949. (Feb. 21.) "Mechanised Trial and Error : Some Examples of Electrical Automatic Control." By Professor F. C. WILLIAMS, O.B.E.

RAMSDEN MEMORIAL LECTURES.

1949. (Dec. 12.) "The Changing Face of Medicine." By Professor CRIGHTON BRAMWELL, M.D., F.R.C.P.

Awards of the Dalton Medal.

1898. EDWARD SCHUNCK, Ph.D., F.R.S.

1900. Sir HENRY E. ROSCOE, F.R.S.

1903. Professor OSBORNE REYNOLDS, LL.D., F.R.S.

1919. Professor Sir ERNEST RUTHERFORD, M.A., D.Sc., F.R.S.

1931. Sir JOSEPH J. THOMSON, O.M., D.Sc., F.R.S.

1942. Sir LAWRENCE BRAGG, O.B.E., M.C., F.R.S., D.Sc., M.A.

1948. Professor P. M. S. BLACKETT, F.R.S.

A detailed list of the medals, awarded to John Dalton and others, which are the property of the Society, will be found in Memoirs and Proceedings, Vol. 84, 1939–41, *pp.* xxxi—xxxiii.

A DETAILED LIST OF ARTICLES SALVAGED.

FROM 36, GEORGE STREET, MANCHESTER, AFTER THE DESTRUCTION OF THE BUILDING ON DECEMBER 24TH, 1940, WILL BE FOUND IN *Memoirs and Proceedings*, VOL. 84, 1939–41, *pp.* xxxiv—xxxvii.

LIST OF PRESIDENTS OF THE SOCIETY.

Date of Election.	
1781.	PETER MAINWARING, M.D., JAMES MASSEY.
1782–1786.	JAMES MASSEY, THOMAS PERCIVAL, M.D., F.R.S.
1787–1789.	JAMES MASSEY.
1789–1804.	THOMAS PERCIVAL, M.D., F.R.S.
1805–1806.	REV. GEORGE WALKER, F.R.S.
1807–1809.	THOMAS HENRY, F.R.S.
1809.	*JOHN HULL, M.D., F.L.S.
1809–1816.	THOMAS HENRY, F.R.S.
1816–1844.	JOHN DALTON, D.C.L., F.R.S.
1844–1847.	EDWARD HOLME, M.D., F.L.S.
1848–1850.	EATON HODGKINSON, F.R.S., F.G.S.
1851–1854.	JOHN MOORE, F.L.S.
1855–1859.	SIR WILLIAM FAIRBAIRN, Bart., LL.D., F.R.S.
1860–1861.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1862–1863.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1864–1865.	ROBERT ANGUS SMITH, Ph.D., F.R.S.
1866–1867.	EDWARD SCHUNCK, Ph.D., F.R.S.
1868–1869.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1870–1871.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1872–1873.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1874–1875.	EDWARD SCHUNCK, Ph.D., F.R.S.
1876–1877.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1878–1879.	JAMES PRESCOTT JOULE, D.C.L., F.R.S.
1880–1881.	EDWARD WILLIAM BINNEY, F.R.S., F.G.S.
1882–1883.	SIR HENRY ENFIELD ROSCOE, D.C.L., F.R.S.
1884–1885.	WILLIAM CRAWFORD WILLIAMSON, LL.D., F.R.S.
1886.	ROBERT DUKINFIELD DARBISHIRE, B.A., F.G.S.
1887.	BALFOUR STEWART, LL.D., F.R.S.
1888–1889.	OSBORNE REYNOLDS, LL.D., F.R.S.
1890–1891.	EDWARD SCHUNCK, Ph.D., F.R.S.

* Elected April 28th; resigned office May 5th.

Date of Election.	
1892–1893.	ARTHUR SCHUSTER, Ph.D., F.R.S.
1894–1896.	HENRY WILDE, D.C.L., F.R.S.
1896.	EDWARD SCHUNCK, Ph.D., F.R.S.
1897–1899.	JAMES COSMO MELVILL, M.A., F.L.S.
1899–1901.	HORACE LAMB, M.A., F.R.S.
1901–1903.	CHARLES BAILEY, M.Sc., F.L.S.
1903–1905.	W. BOYD DAWKINS, M.A., D.Sc., F.R.S.
1905–1907.	SIR WILLIAM H. BAILEY, M.I.Mech.E.
1907–1909.	HAROLD BAILY DIXON, M.A., F.R.S.
1909–1911.	FRANCIS JONES, M.Sc., F.R.S.E.
1911–1913.	F. E. WEISS, D.Sc., F.L.S.
1913–1915.	FRANCIS NICHOLSON, F.Z.S.
1915–1917.	SYDNEY J. HICKSON, M.A., D.Sc., F.R.S.
1917–1919.	WILLIAM THOMSON, F.R.S.E., F.C.S., F.I.C.
1919.	G. ELLIOT SMITH, M.A., M.D., F.R.S.
1919–1921.	SIR HENRY A. MIERS, M.A., D.Sc., F.R.S.
1921–1923.	T. A. COWARD, M.Sc., F.Z.S., F.E.S.
1923–1925.	H. B. DIXON, C.B.E., M.A., Ph.D., M.Sc., F.R.S., F.C.S.
*1925.	REV. A. L. CORTIE, S.J., D.Sc., F.R.A.S., F.Inst.P.
1925–1927.	H. LEVINSTEIN, D.Sc., M.Sc., F.I.C.
1927–1929.	W. L. BRAGG, O.B.E., M.A., F.R.S.
1929–1931.	C. E. STROMEYER, O.B.E., M.Inst.C.E.
1931–1933.	B. MOUAT JONES, D.S.O., M.A.
1933–1935.	JOHN ALLAN, F.C.S.
1935–1937.	R. W. JAMES, M.A., B.Sc.
1937–1939.	R. H. CLAYTON, M.Sc.
1939–1940.	D. R. HARTREE, M.A., Ph.D., M.Sc., F.R.S.
1940–1944.	H. J. FLEURE, M.A., D.Sc., F.R.S.
1944–1946.	M. POLANYI, Ph.D., M.Sc., M.D., F.R.S.
1946–1948.	T. B. L. WEBSTER, M.A.
1948–1950.	E. J. F. JAMES, M.A., D.Phil.

* Died May 16th, 1925.

LIST OF HONORARY MEMBERS OF THE SOCIETY.

Date of Election.	
Apr. 26th, 1892.	C. LIEBERMANN.
Apr. 17th, 1894.	A. GOUY.
do.	SIDNEY VINES.
Apr. 17th, 1894.	EMIL WARBURG.
Apr. 30th, 1895.	SIR JOSEPH JOHN THOMSON, O.M.
Apr. 24th, 1900.	SIR J. ALFRED EWING.
do.	ANDREW RUSSELL FORSYTH.
do.	ROBERT RIDGEWAY.
May 13th, 1902.	SIR JOSEPH LARMOR.
do.	SIR OLIVER LODGE.
Apr. 28th, 1903.	FRANK WIGGLESWORTH CLARKE.
Apr. 5th, 1910.	WALTHER NERNST.
Nov. 28th, 1922.	NIELS BOHR.
Apr. 13th, 1926.	SAMUEL ALEXANDER, O.M.
do.	ARNOLD SOMMERFELD.
Nov. 16th, 1926.	SIDNEY J. HICKSON.
do.	SIR HENRY A. MIERS.
May 13th, 1930.	F. E. WEISS.
Apr. 29th, 1947.	H. J. FLEURE, M.A., D.Sc., F.R.S.
Oct. 17th, 1949.	HARRY BRITTEN.

LIST OF CORRESPONDING MEMBERS OF THE SOCIETY.

Date of Election.	
Feb. 3rd, 1920.	W. S. MURPHEY.
Nov. 1st, 1921.	MRS. C. W. PALMER.
Nov. 29th, 1923.	H. F. COWARD.
Apr. 1st, 1924.	G. F. FOWLER.
Dec. 16th, 1924.	G. SENN.
Oct. 13th, 1925.	H. G. A. HICKLING.
Nov. 11th, 1941.	MISS E. OWEN.
Dec. 12th, 1944.	H. J. FLEURE.
Oct. 18th, 1948.	D. C. HENRY.
	JOHN ALLAN.
Dec. 13th, 1948.	W. H. LANG.

THE COUNCIL
OF THE
MANCHESTER
LITERARY AND PHILOSOPHICAL SOCIETY.
FOUNDED 1781.

Elected April 27th, 1949, *for the Session* 1949–50.

President.

E. J. F. JAMES, M.A., D.Phil.

Vice-Presidents.

M. POLANYI, M.D., Ph.D., M.Sc., F.R.S.
MISS A. C. ALEXANDER, B.Sc.
J. KENNER, D.Sc., Ph.D., F.R.S.
N. SMITH, D.Sc., F.C.S.

Hon. Secretaries.

G. F. CLAYTON.
J. G. ROGER, B.Sc., F.L.S.

Assistant Secretary.

MISS JEAN ARMITT.

Hon. Treasurer.

H. HAYHURST, F.R.I.C., A.M.I.Chem.E., F.R.E.S.

Hon. Librarians.

W. H. BRINDLEY, M.C., M.A., M.Sc., Ph.D
MISS D. EMMET, M.A.

Hon. Curator.

J. R. ASHWORTH, D.Sc.

Council.

Miss E. M. LIND, B.Sc., Ph.D.
M. H. A. NEWMAN, F.R.S.
R. N. SPANN, M.A.
P. GUTHLAC JONES.
WRIGHT GARSIDE.
NEIL PEARSON, M.B.E., M.A.
C. J. T. CRONSHAW, D.Sc., M.I.Chem.E., F.S.S., F.R.I.C.
J. H. CLAYTON.
P. F. R. VENABLES, Ph.D., B.Sc., F.R.I.C.

Chemical Section.

Chairman : E. N. MARCHANT, A.R.I.C.
Secretary : H. STEVENSON, F.R.I.C.

Social Philosophy Section.

Chairman : B. A. WORTLEY, O.B.E., LL.M., LL.D.
Secretary : R. N. SPANN, M.A.

LIST OF SOCIETIES AND INSTITUTIONS

TO WHICH THE *Memoirs and Proceedings* ARE SENT.

Societies and Institutions present their publications to the Society's Library with the exception of those marked with a dagger (†).

Aberystwyth. †National Library of Wales.
Abo. Akademie Bibliotek.
Adelaide. Royal Society of South Australia. South Australian Museum. Public Library Museum and Art Gallery of South Australia.
Amsterdam. Koninkliijke Akademie van Wetenschappen. Société Mathématique. Bibliothek van het Wickundig en Genootschap.
Auckland. The Auckland Institute and Museum.
Augsburg. Der naturwissenschaftliche Verein für Schwaben.

Baltimore. John Hopkins University.
Bamberg. Naturforschende Gesellschaft.
Bangalore (Madras). Indian Institute of Science.
Basle. Naturforschende Gesellschaft. Naturforsch. Gesellsch. Universitats.-Bibliothek.
Batavia. Chronica Naturae.
Berkley. University of California.
Berlin. Deutsche Akademie der Wissenschaften zu Berlin. Deutsche Geologische Landesanstalt.
Birmingham. Natural History and Philosophical Society.
Bloemfontein. National Museum.
Bonn. Naturhistorischer Verein der Rheinlande und Westfalens.
Bordeaux. Proces Verbaux des Seances de la Société des Sciences.
Boston. American Academy of Arts and Sciences.
Boulder. University of Colorado.

Brisbane. Royal Geographical Society of Australasia. Queensland Museum. Royal Society of Queensland.

Bristol. Naturalists' Society.

Brno. Faculty of Science, Masaryk University.

Brooklyn (N.Y.). Institute of Arts and Sciences.

Brussels. Institut Royal des Sciences Naturelles de Belgique. Académie Royale de Belgique. Société Belge de Géologie Paléontologie et Hydrologie.

Buckhurst Hill. Essex Field Club.

Buenos Aires. Sociedad Cientifica Argentina.

Buffalo. Society of Natural Sciences.

Calcutta. Agricultural Research Institute (Pusa). Geological Survey of India. Indian Association for the Cultivation of Science. Meteorological Department of India (Poona). Royal Asiatic Society of Bengal.

Cambridge. Philosophical Society.

Cambridge (Mass.) Harvard College. †Massachusetts Institute of Technology Library.

Canberra. National Library.

Cape Town. Royal Society of South Africa. South African Museum.

Cardiff. Naturalists' Society.

Changsa. Geological Survey of China.

Chapel Hill. Elisha Mitchell Scientific Society.

Cherbourg. Société nationale des Sciences naturelles.

Chicago. Astrophysical Journal. Field Museum of Natural History. University of Chicago Library.

Cincinnati. Lloyd Library and Museum. †American Association for the Advancement of Science. Society of Natural History.

Colorado Springs. Colorado College Coburn Library.

Columbia. University of Missouri.

Columbus. Ohio Journal of Science. Ohio State University.

Copenhagen. Kongeligt Danske Videnskabernes Selskab. Naturhistorisk Forening.

Cracow. Société Polonaise Mathématique.

Delft. Technische Hoogeschool.
Dijon. Académie des Sciences, Arts et Belles-Lettres.
Draguignan. Société d'études scientifiques et archéologiques.
Dublin. Royal Dublin Society. Royal Irish Academy.
Durban. †Corporation Museum.

Edinburgh. Botanical Society. Mathematical Society. Royal Physical Society.

Frankfurt-am-Main. Senckenbergische Naturforschende Gesellschaft.
Freiburg i. Br. Naturforschende Gesellschaft.

Geneva. Compte Rendu des Seances.
Genova. Museo Civico di Storia Naturale.
Giessen. Oberhessische Gesellschaft für Natur-und Heilkunde. (Hessen) Deutschland.
Glasgow. †University Library.
Göteborg. Göteborgs Stadtsbibliotek (Högskole).
Graz. Verein der Arzte in Steiermark.

Haarlem. Musée Teyler. Geologische Kaart. Hollandsche Maatschappy der Wetenschappen. Maatschappij-Belangen. Geologische Stichting.
Halifax, N.S. Nova Scotian Institute of Science.
Halle. Deutsche Akademie der Naturforscher.
Hartford (Conn.). Connecticut State Library (Geological and Natural History Survey).
Heidelberg. Naturhistorisch-Medizinscher, Verein zu Heidelberg.
Helsingfors. Finska Vetenskaps Societeten. Societas pro Fauna et Flora Fennica.
Hobart. Royal Society of Tasmania.
Hong Kong. Royal Observatory.

Indianapolis. Department of Geology and Natural Resources of Indiana.
Iowa City. Iowa State University. Iowa Geological Survey.
Ithaca. Cornell University. Agricultural Experimental Station.

Jassy. Bulletin de l'ecole polytechnique de Jassy, Roumania.

Johannesburg. South African Association for the Advancement of Science.

Kiel. Institut für Meereskunde der Universität Kiel.

Kyoto. College of Science, The University.

Lausanne. Société Vaudoise des Sciences Naturelles.

Lawrence. Kansas University.

Leeds. Philosophical and Literary Society. Yorkshire Geological Society.

Leeuwarden. Friesch Genootschap, van Geschied-, Oudheid -en Taalkunde.

Leiden. Maatschappig der Nederlandsch Letterkunde. Rijks Geologisch—Mineralogisch Museum. Rijks Herbarium. Société Néerlandaises de Zoologie.

Leipzig. Sachsische-Akademie der Wissenschaften.

Le Mans. Société d'Agriculture, Sciences et Arts de la Sarthe.

Liége. Société Géologique de Belgique. Société Royale des Sciences.

Lille. Société des Sciences d'Agriculture et des Arts. L'Universitaire.

Lincoln, U.S.A. Nebraska Geological Survey. University of Nebraska.

Lisbon. Observatorio Central Meteorologico. Observacões meteorologicas da Madeira.

Liverpool. Biological Society. Engineering Society. Geological Society. Hartley Botanical Laboratories. Literary and Philosophical Society.

London. British Association. British Museum (Natural History). British Museum (Library of Pure and Applied Science). British Museum Copyright Office. Chemical Society. Faraday Society. Geological Society. Institution of Civil Engineers. Institution of Electrical Engineers. Institution of Mechanical Engineers. Linnean Society. Mathematical Society. Meteorological Office. National Central Library. Patent Office. Physical Society. Quekett Microscopical Society. Royal Society. Royal Astronomical Society. Royal Geographical Society. Royal Horticultural

Society. Royal Institute of British Architects. Royal Institution of Great Britain. Royal Meteorological Society. Royal Observatory. Royal Society of Arts. †Subject Index to Periodicals. University Library. Zoological Society.

Lund. The University Library.

Luxembourg. Institut Grand Ducal de Luxembourg.

Lyon. Académie des Sciences. L'Université.

Madison. Wisconsin Academy of Sciences, Arts and Letters, Wisconsin Geological and Natural History Survey.

Madras. Observatory (Kodaikanal). University.

Madrid. Academia de Ciencias. Sociedad Matemática Española.

Manchester. Association of Engineers. †Chetham's Library. †Christie Library. Conchological Society. Geographical Society. Geological Association. Microscopical Society. †Municipal College of Technology. †Central Library. Shirley Institute. Statistical Society. Textile Institute.

Manhattan. Library of Kansas State College of Agriculture and Applied Science.

Manila. Bureau of Science. Ethnological Survey.

Marseilles. Faculté des Sciences de l'Université.

Melbourne. Royal Society of Victoria.

Metz. Académie de Metz.

Mexico. Instituto Geológico. Academia Nacional de Ciencias. "Antonio Alzate."

Middleburg. Zeeuwsch Genootschap der Wetenschappen.

Milan. Osservatorio Astronomico di Merate (Como). Reale Istituto Lombardo di Scienze e Lettere. Società Italiana di Scienze Naturali, e Museo Civico.

Minneapolis. University of Minnesota. †Academy of Natural Sciences.

Missoula. University of Montana.

Montevideo. Museo de Historia Natural.

Montpellier. Académie des Sciences et Lettres.

Munich. Bayerische Akademie der Wissenschaften.

Nancy. Société des Sciences de Nancy.

Neuchâtel. Société neuchâteloise des Sciences naturelles.

New Haven (Conn.). Connecticut Academy of Arts and Sciences. Bingham Oceanographic Collection.

New York. Academy of Sciences. American Chemical Society. American Mathematical Society. American Museum of Natural History. Meteorological Observatory (Central Park). The Vanderbilt Marine Museum.

Nîmes. Académie de Nîmes.

Norman. Oklahoma Academy of Science.

Norwich. Norfolk and Norwich Naturalists' Society.

Oslo. Norske Videnskaps Akademie. Norsk Meteorologisk Institut. Observatorium. Bibliothèque de l'Université Royale de Norvège.

Ottawa. Dominion Astrophysical Observatory. Geological Survey of Canada. Royal Society of Canada.

Oxford. †Bodleian Library. Radcliffe Library.

Paris. Académie des Sciences. École nationale supérieure des Mines. École polytechnique. Muséum d'Histoire naturelle.

Peiping. Geological Society of China.

Philadelphia. Academy of Natural Sciences. American Philosophical Society. Franklin Institute. †Philadelphia Commercial Museum. Wagner Free Institute of Science.

Pietermaritzburg. †Government Geologist, Surveyor General's Office. Natal Government Museum.

La Plata. Direccion General de Estadistica de la Prov. Buenos Aires. Universidad Nacional. Facultad de Ciencias Fisico-Matematicas.

Plymouth. Plymouth Institution and Devon and Cornwall Natural History Society.

Prague. Bohmische Gesellschaft der Wissenchaft. Publications de l'observatoire national de Prague. Bulletin of the Astronomical Institutes of Czechoslovakia.

Pretoria. The University.

Rennes. Société Scientifique de Bretagne.

Rheims. Académie nationale.

La Rochelle. Société des Sciences naturelles de la Charente inférieure.

Rochdale. Literary and Scientific Society.

Rochester, N.Y. Academy of Science.
Rock Island. Augustana College Library.
Rome. Institut International d'Agriculture. Reale Accademia dei Lincei. Società Italiana per il progresso delle Scienze. Vatican Observatory (Specola Vaticana).
Rouen. Académie des Sciences.

Sacramento. See Berkeley.
St. Louis. Missouri Botanical Garden. †Academy of Science. The Washington University.
St. Paul. See Minneapolis.
Salford. †Royal Museum and Library.
San Diego. Society of Natural History.
San Francisco. California Academy of Sciences.
Santiago. Deutscher wissenschaftlicher Verein.
Seattle. University of Washington. Oceanographical Laboratories. Puget Sound Marine Biological Station.
Sendai. Tohoku Library University.
Simla. See Calcutta.
Southport. Fernley Observatory.
Stockholm. Entomologiska Föreningen. Kongeliga Svenska Vetenskaps-Akademi. Royal Library. Sveriges Geologiska Undersökning. Stockholms Högkolas Bibliotek.
Stoke-upon-Trent. North Staffordshire Field Club.
Stratford. The Essex Field Club.
Swansea. Scientific and Field Naturalists' Society.
Sydney. Australian Museum. Linnean Society of New South Wales. Royal Society of New South Wales.

Taihoku. Scientific Research Institute Ltd., National Research Council of Japan.
Toronto. University Library.
Toulouse. Académie des Sciences, Inscriptions, et Belles-Lettres.
Trondhjem. Kongelige Norske Videnskabers Selskab Museet.
Troyes. Société Académique d'Agriculture de l'Aube.
Tufts, Massachusetts. Tufts College.

Uccle. L'Observatoire royale et l'Institut royal Météorologique de Belgique.

Upsala. Kongeliga Universitet. Kongeliga Vetenskaps-Societeten.

Urbana. Illinois State Geological Survey. Illinois State Laboratory of Natural History. University of Illinois.

Utrecht. Koninklijk Nederlandsch Meteorologisch Instituut. Provincial Utrechtsch Genootschap van Kunsten en Wetenschappen.

Victoria, B.C. Dominion Astrophysical Observatory.

Vienna. Akademie der Wissenschaften in Wien. Naturhistorisches Museum.

Washington University. See St. Louis, Mo.

Washington, University of. See Seattle.

Washington, D.C. Bureau of Standards, Dept. of Commerce and Labor. Carnegie Institute. Smithsonian Institution, Bureau of Ethnology. Smithsonian Institution, United States National Museum. U.S. Coast and Geodetic Survey. U.S. Department of Agriculture. U.S. Geological Survey. U.S. Naval Observatory. †U.S. Patent Office.

Wellington, N.Z. Royal Society of New Zealand.

Wiesbaden. Nassauischer Verein für Naturkunde.

Wuppertal-Elberfeld. Naturwissenscaftlicher Verein.

Wurzburg. Physikalisch-medizinische Gesellschaft.

York. Yorkshire Philosophical Society.

Zürich. Naturforschende Gesellschaft. Schweizerischer Meteorologische Central-Anstalt.

LIST OF ORDINARY MEMBERS OF THE SOCIETY, FEBRUARY, 1950.

Year of Election.

1920. Miss A. C. Alexander, B.Sc., c/o Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1942. Dr. Alexander Altmann, 38, Waterpark Road, Salford, 7.

1946. F. H. Angold, 470, Moss Lane East, Manchester, 14.

1928. G. E. Archer, M.B., Ch.B., D.L.O., F.R.C.S.(Ed.), West Thorpe, Park Road, Bowdon, Cheshire.

1945. Godfrey Armitage, 3, Didsbury Park, Manchester, 20.

1945. Mrs. G. Armitage, 3, Didsbury Park, Manchester, 20.

1943. A. Leslie Armstrong, M.C., M.Sc., F.S.I., F.S.A., 27, Victoria Road, Stockton Heath, Warrington.

1926. J. R. Ashworth, D.Sc., 55, King Street South, Rochdale.

1946. Miss E. E. Backhouse, 32, Panton Street, Cambridge.

1920. F. W. Bailey, Haven House, Broadbottom, Cheshire.

1940. Mrs. E. A. Bardsley, Alexander Hotel, Alexandra Road, Southport.

1945. Lady Barlow, Dene House, Lancaster Road, Didsbury, Manchester, 20.

1947. M. S. Bartlett, Department of Mathematics, The University, Manchester, 13.

1949. G. Bell, c/o Messrs. Tootal Broadhurst Lee Co. Ltd., Research Dept., 56, Oxford Street, Manchester, 1.

1947. A. H. Birch, 18, Plumbleu Drive, Old Trafford, Manchester, 16.

1948. Miss M. McLeod Black, M.A., 1, Belmore Avenue, Higher Crumpsall, Manchester, 8.

1937. Professor P. M. S. Blackett, M.A., F.R.S., The University, Manchester, 13.

1945. John Boardman, B.Com. (Lond.), 11, Parkfield Road, Cheadle Hulme, Cheshire.

Year of Election.

1945. W. R. Boon, B.Sc., Ph.D., F.R.I.C., 37, Hawthorn Lane, Wilmslow, Cheshire.

1949. Miss J. F. E. Bounds, " Cherfold ", Kempnough Hall Road, Worsley.

1914. Frank Bowman, M.A., M.Sc.Tech., 12, Clifton Avenue, Fallowfield, Manchester, 14.

1947. Professor A. M. Boyd, 64, Platt Lane, Manchester, 14.

1914. Major A. W. Boyd, M.C., M.A., F.R.E.S., Frandley House, Nr. Northwich, Cheshire.

1945. Miss Bozman, Manchester High School for Girls, Grangethorpe Road, Manchester, 14.

1927. J. Crighton Bramwell, M.A., M.D., F.R.C.P., 15, Lorne Street, Manchester, 13.

1945. Ronald Brightman, M.Sc., A.C.G.F.C., F.R.I.C., 19, Danesway, Prestwich, Nr. Manchester.

1936. W. H. Brindley, M.C., M.A., M.Sc., Ph.D., 11, Pikes Lane, Glossop, Derbyshire.

1947. P. M. Bromley, B.A., Donner House, Oak Drive, Fallowfield, Manchester, 14.

1948. Mrs. Brook, 26, Chandos Road South, Manchester, 21.

1934. Ernest Brunner, Ph.D., Oak Tree Cottage, Castle Hill, Prestbury.

1929. H. E. Buckley, D.Sc., Bradda, Hazelhurst Road, Worsley, Lancs.

1945. R. F. I. Bunn, 169, Burton Road, West Didsbury, Manchester, 20.

1949. Mrs. S. B. Bunn, M.A., 169, Burton Road, Manchester, 20.

1949. N. H. Burdett, M.A., 230, Stretford Road, Urmston.

1925. G. N. Burkhardt, M.Sc., Ph.D., F.I.C., The University, Manchester, 13.

1941. Miss A. Burton, Slethos House, 68, Sackville Street, Manchester, 1.

1949. P. W. Campbell, B.A., Donner House, Oak Drive, Manchester, 14.

1920. Miss Marion Chadwick, M.Sc.Tech., 1, Didsbury Road, Stockport.

Year of Election.

1899. D. L. Chapman, M.A., F.R.S., Jesus College, Oxford.
1943. Professor H. B. Charlton, The University, Manchester, 13.
1949. Rev. F. G. Chevassut, 156, Chester Road, Manchester, 15.
1943. S. E. Chiotides, 29, Minshull Street, Manchester, 1.
1946. P. Chorley, M.Sc., A.R.I.C., 32, St. Michaels Avenue, Bramhall, Cheshire.
1929. J. D. Chorlton, M.Sc., 62, Palatine Road, Withington, Manchester, 20.
1939. G. F. Clayton, 7, College House, South Downs Road, Bowdon.
1948. Mrs. G. F. Clayton, 7, College House, South Downs Road, Bowdon.
1929. J. H. Clayton, Lymm Hall, Lymm, Cheshire.
1945. Mrs. John Coatman, c/o The Firs, Fallowfield, Manchester, 14.
1949. Leonard Cohen, 21, Parkwood Road, Wythenshawe.
1945. W. Mansfield Cooper, The University, Manchester, 13.
1949. O. R. Corbett, B.A., 13, Gaddum Road, Didsbury, Manchester, 20.
1924. C. G. Core, M.Sc., Greystoke, Palatine Road, Manchester, 20.
1947. R. J. Cornish, M.Sc., College of Technology, Manchester, 1.
1949. R. G. Cox, 61, Northenden Road, Sale.
1949. Mrs. R. G. Cox, 61, Northenden Road, Sale.
1934. Miss R. E. S. Cox, The Bungalow, Park Road, Monton, Eccles.
1916. Mrs. M. B. Craven (Life Member), M.Sc.Tech., The College of Technology, Manchester, 1.
1943. H. S. Critchley, "Three Gates," Higher Disley, Cheshire.
1945. Dr. C. J. T. Cronshaw, "Alnwick," Prestwich Park, Prestwich, Nr. Manchester.
1919. Dr. Mary Cunningham, D.Sc., 27, Clarence Terrace, Bollington, Nr. Macclesfield.
1923. George W. Cussons, The Technical Works, Lower Broughton, Salford, 7.

Year of Election.

1929. J. A. Darbyshire, M.Sc. (Life Member), "Melandra," Kershaw Road, Failsworth, Manchester.

1950. W. H. H. Demuth, M.C., M.A., B.Sc., Lower Riddings, Hartford, Cheshire.

1946. E. Devons, 1, Darley Avenue, Manchester, 20.

1918. Miss Annie Dixon, M.Sc., F.R.M.S. (Life Member), Kauguri, Batchford Drive, St. Albans.

1947. Professor S. Dobrin, The University, Manchester, 13.

1950. W. K. Donaldson, Ph.D., 74, Russell Street, Manchester, 16.

1945. Professor Dorothy Emmet, M.A., 21, Yew Tree Lane, Northenden, Manchester.

1950. J. S. Eros, 25, Moorland Road, Manchester, 20.

1945. Dr. A. G. Evans, Chemistry Department, The University, Manchester, 13.

1949. Miss Dorothy Evans, Longcroft, Old Road, Mottram.

1946. B. S. E. Farrow, Esq., 82, Woodford Road, Bramhall, Cheshire.

1942. W. R. Fielding, M.A., M.Sc., M.Ed., Manor House, Manor Road, Fleetwood.

1924. Sir A. P. M. Fleming, C.B.E., Metropolitan-Vickers Electrical Co. Ltd., Trafford Park, Manchester, 17.

1932. Professor H. J. Fleure, M.A., D.Sc., F.R.S., 275, Church Road, London, S.E.19.

1940. R. P. Foulds, M.Sc., F.I.C., F.T.I., c/o Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1947. Wright Garside, Brereton, Ogden Road, Bramhall, Cheshire.

1950. Herbert Gartside, B.Sc., Ph.C., 231, Brantingham Road, Manchester, 21.

1922. P. Gaunt, F.R.I.C. (Life Member), Ladybarn, Letchworth, Herts.

1949. M. B. Gibbs, Audenshaw Grammar School, Audenshaw.

1950. Wilfrid Gibson, 76, Cavendish Road, Salford, 8.

1922. A. Gill, B.Sc., A.I.C., Hardwick, 30, Woodhill Drive, Prestwich, Nr. Manchester.

Year of Election.

1947. Professor S. Goldstein, The University, Manchester, 13.

1947. A. H. Goulty, M.A., 7, Didsbury Park, Manchester, 20.

1947. Mrs. A. H. Goulty, M.A., 7, Didsbury Park, Manchester, 20.

1926. W. Howard Goulty (Life Member), Cornbrook, Mortimer Common, Berkshire.

1947. Herbert Gudgeon, 16, Ash Walk, Alkrington, Middleton, Lancs.

1946. W. Hagenbuch, 195, Gilbert Road, Cambridge.

1945. A. J. Hailwood, B.Sc., 3, Hazel Road, Altrincham.

1946. H. Hartley, 84, Macclesfield Road, Buxton, Derbyshire.

1929. Professor D. R. Hartree, M.A., Ph.D., F.R.S. (Life Member), 21, Bentley Road, Cambridge.

1950. R. N. Haward, 42, Ullswater Road, Flixton.

1943. Miss M. V. Malcolm-Hayes, Mayfield, The Hough, Wilmslow, Cheshire.

1924. H. Hayhurst, F.R.I.C., A.M.I.Chem.E., F.R.E.S. (Life Member), Fouray, Parkfield Road, Didsbury, Manchester, 20.

1924. Mrs. H. Hayhurst, M.Sc. (Life Member), Fouray, Parkfield Road, Didsbury, Manchester, 20.

1948. Edgar Heald, Fernbank, Stenner Lane, Didsbury, Manchester, 20.

1948. Alexander Henderson, M.A., Economics Department, The University, Manchester, 13.

1919. D. M. Henshaw, c/o Messrs. W. C. Holmes & Co. Ltd., Engineers, Huddersfield.

1946. H. Hepworth, D.Sc., F.R.I.C., 115, Manchester Road, Wilmslow, Cheshire.

1928. J. B. M. Herbert, M.Sc., The University, Manchester, 13.

1942. Professor D. H. Hey, King's College, Strand, London, W.C.2.

H. C. Longuet-Higgins, Hulme Hall, Victoria Park, Manchester, 13.

Year of Election.

1948. W. D. Hincks, Department of Entomology, Manchester Museum, The University, Manchester, 13.

1944. Samuel Hird, O.B.E., M.Sc., 12, Oaklands Avenue, Stockport.

1936. K. G. Holden, B.A., "Downshot," Alderley Edge, Cheshire.

1936. N. N. Holden, "Downshot", Alderley Edge, Cheshire.

1943. Ernest Hollings, Dunleath, 17, Alexandra Road, Sale, Cheshire.

1944. Rev. R. V. Holt, M.A., B.Litt., Unitarian College, Victoria Park, Manchester, 14.

1947. J. A. Hornby, B.A., 687, Blackburn Road, Bolton.

1920. T. Horner, M.Sc.Tech., A.I.C. (Life Member), Bronwylfa, Plasuchaf Avenue, Prestatyn, North Wales.

1926. O. R. Howell, B.Sc., Ph.D., Spey Lodge, 29, Palatine Road, Withington, Manchester, 20.

1945. N. S. Hubbard, Broughton Copper Works, P.O. Box 346, Manchester.

1919. Henry Humphreys, 101, Frederick Street, Oldham.

1945. B. de Courcy Ireland, B.A., 22, Alan Road, Withington, Manchester, 20.

1945. Dr. E. J. F. James, M.A., D.Phil., The Grammar School, Manchester, 14.

1945. Mrs. E. J. F. James, 143, Old Hall Lane, Fallowfield, Manchester, 14.

1923. R. W. James, B.Sc., The University, Cape Town, South Africa.

1943. Professor Geoffrey Jefferson, High Bank, Stenner Lane, Didsbury, Manchester, 20.

1943. Mrs. Jefferson, High Bank, Stenner Lane, Didsbury, Manchester, 20.

1924. Francis Jones, F.R.I.B.A., 178, Oxford Road, Manchester, 13.

1923. P. Guthlac Jones, Malista, Limefield Road, Kersal, Manchester, 7.

Year of Election.

1949. A. Keller, 761, Rochdale Road, Queen's Park, Manchester, 9.

1945. J. T. Kendall, M.A., 19a, Edith Grove, London, S.W.10.

1928. Professor J. Kenner, D.Sc., Ph.D., F.R.S., The College of Technology, Manchester, 1.

1940. C. M. Keyworth, M.Sc., F.I.C., A.M.I.Chem.E., "Prenton," Buxton Road, Leek, Staffs.

1948. E. W. Lambert, M.A., M.Sc., A.R.I.C., F.C.S., 106, Talbot Street, Moss Side, Manchester, 16.

1931. H. S. Land, 24, Hillington Road, Ashton-on-Mersey, Cheshire.

1946. Professor R. E. Lane, 6, Linden Road, Didsbury, Manchester, 20.

1917. Sir Kenneth Lee, LL.D., Messrs. Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1940. H. R. Leech, The Lindens, Balmoral Road, Grappenhall, Nr. Warrington.

1948. F. N. Lees, 2, Albany Road, Victoria Park, Manchester, 14.

1931. Miss C. M. Legge, M.A., A.R.C.A., Lady Mabel College, Wentworth Woodhouse, Rotherham.

1948. A. G. Lehmann, M.A., D.Phil., 30, Derby Road, Manchester, 14.

1943. Miss Myee Dorothy Leigh, M.A., Lyncroft, Higher Ainsworth Road, Radcliffe, Manchester.

1943. Miss Margaret Lever, Lyncroft, Higher Ainsworth Road, Radcliffe.

1948. Professor W. A. Lewis, Department of Economics, The University, Manchester, 13.

1944. Dr. E. M. Lind, B.Sc., Ph.D., Ashburne Hall, Fallowfield, Manchester, 14.

1949. Robert Lomax, B.Sc., Ph.D., 36, High Street, Manchester, 13.

1928. H. Lowery, D.Sc., Ph.D., M.Ed., F.Inst.P., F.C.P., Principal, South-West Essex Technical College, Forest Road, London, E.17.

Year of Election.

1949. W. J. M. MacKenzie, Professor of Government, The University, Manchester, 13.

1941. Rev. H. McLachlan, M.A., D.D., Litt.D., F.R.Hist.S., 11, Sydenham Avenue, Liverpool, 17.

1946. Miss A. MacLennan, 30, Errwood Road, Levenshulme, Manchester, 19.

1945. Mrs. McManus, *Manchester Guardian*, Cross Street, Manchester, 2.

1943. Miss C. E. MacWhirter, 33, Burlington Road, Withington, Manchester, 20.

1947. Thomas Maguire, 10, Great Cheetham Street West, Salford, 7.

1945. Professor T. W. Manson, M.A., B.Litt., D.D., F.B.A., Woodheys, Mersey Road, Heaton Mersey, Stockport, Cheshire.

1931. E. N. Marchant, A.R.I.C., Whetherstones, Wilbraham Road, Chorlton-cum-Hardy, Manchester, 21.

1945. C. H. Marsh, Henry Simon Ltd., Cheadle, Cheshire.

1949. J. T. Marshall, Bent Cottage, Red Lane, Disley.

1941. Dr. A. R. Martin, 30, Styal Road, Wilmslow, Cheshire.

1929. H. G. Mather, Sunnymead, Hamilton Road, Whitefield.

1949. Wolfe Mays, Dept. of Philosophy, The University, Manchester, 13.

1949. R. L. Meire, 24, Brundrett's Road, Chorlton-cum-Hardy, Manchester, 21.

1945. R. R. Melhuish, B.Sc., Ph.D., 10, Hill Top Avenue, Prestwich.

1939. Mrs. A. D. Melland, 17, Ladybarn Road, Fallowfield, Manchester, 14.

1949. Wilfred Merchant, 48, Sandacre Road, Baguley.

1949. Ernest Messenger, Grayrigg, Arkwright Road, Marple.

1939. C. H. Melland, M.D., 17, Ladybarn Road, Fallowfield, Manchester, 14.

1927. W. Melland, M.A., J.P., 1b, Cooper Street, Manchester, 2.

1950. G. D. Miller, B.B.C., Piccadilly, Manchester, 1.

Year of Election.

1936. Professor John Morley, Ch.M., F.R.C.S., The Elms, Wilmslow Road, Didsbury, Manchester, 20.

1912. J. E. Myers, O.B.E., D.Sc., The College of Technology, Manchester, 1.

1945. Professor M. H. A. Newman, F.R.S., The University, Manchester, 13.

1927. J. M. Nuttall, D.Sc., The University, Manchester, 13.

1945. Professor R. A. C. Oliver, The University, Manchester, 13.

1936. T. H. Oliver, M.D., Northern Assurance Buildings, Albert Square, Manchester, 1.

1948. J. M. Owen, Manox House, Canal Street, Miles Platting, Manchester, 10.

1946. C. Paine, B.Sc., Ellesmere, Macclesfield Road, Wilmslow, Cheshire.

1947. Ronald Peacock, M.A., Ph.D., The University, Manchester, 13.

1942. David Pearson, B.A., 16, Greenbank Road, Gatley, Cheadle, Cheshire.

1946. N. G. C. Pearson, M.B.E., M.A., 1, Dickinson Street West, Manchester, 2.

1949. F. T. Perkins, M.Sc., Ph.D., Department of Bacteriology, The University, Manchester, 13.

1946. Miss D. Pilkington, Firwood, Alderley Edge, Cheshire.

1946. Sir Harry Platt, 11, Lorne Street, Manchester, 13.

1946. P. H. Plesch, A.R.I.C., M.A., Department of Chemistry, The University, Manchester, 13.

1934. Professor M. Polanyi, M.D., Ph.D., M.Sc., F.R.S., 10, Gilbert Road, Hale, Cheshire.

1945. F. R. Poskitt, Esq., Bolton School, Bolton, Lancs.

1931. Professor W. J. Pugh, O.B.E., B.A., D.Sc., F.G.S., Rathen House, Spath Road, Didsbury, Manchester, 20.

1923. Professor H. S. Raper, C.B.E., D.Sc., M.B., Ch.B., M.Sc., F.R.S., The University, Manchester, 13.

1945. William Rawlinson, Tan-y-Bryn Road, Rhos-on-Sea.

1929. Dr. W. J. Sutherland Reid, 10, St. John Street, Manchester.

Year of Election.

1946. R. J. W. Reynolds, B.Sc., Ph.D., A.R.I.C., 13, Brierley Drive, Alkrington, Middleton, Lancs.

1920. Professor A. D. Ritchie, M.A. (Life Member), The University, Manchester, 13.

1947. F. C. Robinson, Holmdale, Hargate Drive, Hale, Cheshire.

1909. Miss Rona Robinson, M.Sc., F.I.C. (Life Member), Mosley Villa, Mitford Road, Fallowfield, Manchester, 14.

1947. Brian Rodgers, Department of Economics, The University, Manchester, 13.

1946. J. G. Roger, B.Sc., F.L.S., Manchester Museum, The University, Manchester, 13.

1947. J. D. Rose, B.A., B.Sc., 12, Orford Road, Prestwich.

1948. Professor Rosenfeld, 215, Old Hall Lane, Fallowfield, Manchester, 14.

1947. Richard Rowe, Ph.D., A.R.I.C., Woodroyd, Oldfield Road, Altrincham, Cheshire.

1920. W. A. Silvester, M.Sc. (Life Member), 4, Claremont Road, Cheadle Hulme, Cheshire.

1941. A. P. Simon, Lyndale, West Didsbury, Manchester, 20.

1906. Norman Smith, D.Sc., F.C.S., 22, Broadway, Withington, Manchester, 20.

1946. R. N. Spann, M.A., 17, Brooklyn Crescent, Cheadle, Cheshire.

1926. Wm. Speight, M.Sc., The Grammar School, Manchester, 13.

1911. Miss Laura E. Start, M.Ed., Three Oaks, Marley Road, Exmouth, Devon.

1949. Miss H. Y. Stephen, Millheys, Dale Brow, Prestbury.

1949. Donald Stephenson, O.B.E., Stonecroft, Parkfield Road, Manchester, 20.

1921. H. Stevenson, F.R.I.C., 31, Barchester Road, Cheadle, Cheshire.

1949. Eric Simm, M.A., 11, Portland Road, Eccles.

1936. Sir John S. B. Stopford, M.D., Sc.D., F.R.S., The University, Manchester, 13.

Year of Election.

1936. J. F. Straatman, 208, Heywood Road, Prestwich, Nr. Manchester.

1924. Stephen H. Straw, D.Sc., The University, Manchester, 13.

1924. G. A. Sutherland, M.A., Dalton Hall, Victoria Park, Manchester, 14.

1938. H. Frankland Taylor (Life Member), Innisfree, Lynne Road, Disley, Cheshire.

1945. Sir John Taylor, 12, Exchange Street, Manchester, 2.

1919. F. H. Terleski, Oakwood, Hilton Lane, Prestwich, Manchester.

1949. A. G. Thompson, Tootal Broadhurst Lee Co. Ltd., 56, Oxford Street, Manchester, 1.

1949. A. W. Thompson, Ph.D., M.B.E., 3, Brook Road, Fallowfield, Manchester, 14.

1921. Professor F. C. Thompson, B.Sc., M.Sc., D.Met., The University, Manchester, 13.

1942. H. T. Thorp, " Beechwood," Pinfold Lane, Whitefield, Manchester.

1931. F. C. Toy, D.Sc., Tregays, Fletsand Road, Wilmslow, Cheshire.

1936. Miss H. L. Tuer, 8, The Garth, Yarnton, Oxford.

1931. H. A. Turner, M.Sc., A.I.C. (Life Member), Ministry of Supply, Chemical Defence, Research Station, Porton, Wilts.

1947. P. F. R. Venables, Ph.D., B.Sc., F.R.I.C., Royal Technical College, Peel Park, Salford, 5.

1944. Miss Emily Verity, B.Sc., 19, Wellington Road, Fallowfield, Manchester, 14.

1921. H. Walkden (Life Member), The Raft, Derbyshire Road, Sale, Cheshire.

1944. Professor R. D. Waller, M.B.E., M.A., Extra-Mural Department, The University, Manchester, 13.

1949. E. G. Warburton, 148, Wilmslow Road, Didsbury, Manchester, 20.

1946. Professor C. W. Wardlaw, The University, Manchester, 13.

Year of Election.

1936. Professor T. B. L. Webster, M.A., University College, Gower Street, London, W.C.1. (Life Member).

1943. Frank W. Whaley, M.Sc., 126, Shaw Heath, Stockport.

1919. A. F. Williams, Kenyon Clough, Helmshore, near Manchester.

1946. D. G. M. Williams, Red Acre, Macclesfield Road, Alderley Edge.

1920. J. C. Withers, Ph.D., A.R.I.C., The Shirley Institute, East Didsbury, Manchester, 20.

1945. Professor B. A. Wortley, Faculty of Law, The University, Manchester, 13.

1915. Lord Simon of Wythenshawe, "Broomcroft," Ford Lane, Didsbury, Manchester, 20.

1923. G. E. Yarrow, M.B.E., M.Sc., A.R.I.C., "Dayspring," 13, Lynton Park Road, Cheadle Hulme, Cheshire.

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